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3. References and Footnotes. Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

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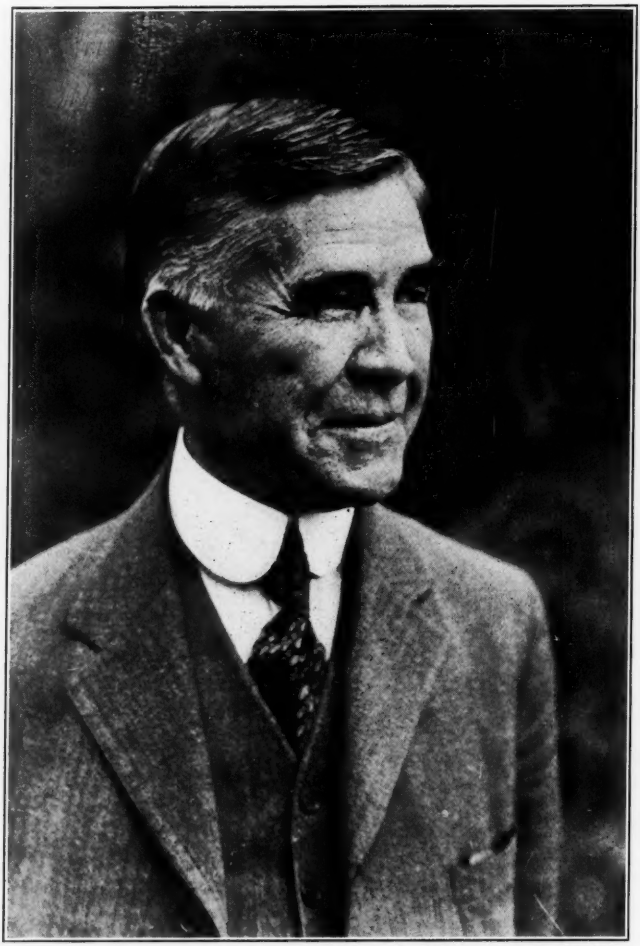

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EDWARD CURTIS FRANKLIN

EDITOR'S OUTLOOK

"DEVOTED teacher, indefatigable investigator, faithful friend"—that is what they say of Dr. Edward Curtis Franklin, soon to retire from active academic pursuits at Stanford University. He came there from the University of Kansas in 1903, as associate professor of chemistry, was raised to full professorship in 1906 and has remained ever since.

Edward Curtis Franklin

The American Chemical Society thinks highly of him, too, for he was elected to its presidency in 1923. Also, in 1925 he was awarded the William H. Nichols medal for an article on "Systems of Acids, Bases, and Salts." It was judged the finest chemical research paper of the year. Numerous other honors have been conferred upon him.

Research has been one of his chief interests ever since he began his investigations with an examination of the behavior of liquid ammonia as an electrolytic solvent. The continuation and expansion of these studies has opened up to the chemical world[1] an entirely new field, centering around the chemistry of nitrogen and ammonia. His liquid air machine which he has used in connection with many of his experiments is said to have more than once endangered his well-being. But the same courageous spirit which has made him such an enthusiastic mountain climber has dominated his whole scientific career.

Searching for a more intimate picture of Edward Franklin, we find that his home has been a social center of campus life. It is what William Allen White,[2] speaks of as a "power-house of joy and inspiration."

> His home, his classroom, his professional office was a lodestone which directed to him all sorts of inquiring, aspiring, and spiritually needy youths, chiefly with a scientific bent. He told them some things, gave them some directions which were not very important, perhaps some instruction which was good, but what he gave them that lasted was affectionate consideration. He could pat a man on the shoulder in trouble and move mountains from it. He was so kind, so just, so penetrating in his sympathy that one never inquired whether he understood; one only knew that he cared anyway.
>
> Now this sort of a character is generally slovenly in his academic work; often lets good nature answer for good scholarship. The marvel of Franklin is that with all the knowledge he acquired, with all the tremendous capacity for detail which he developed in chemistry, he did not atrophy his emotional nature, did not dull his joyous helpful contact with youth.

When his many friends began to discuss the foundation of an Edward Curtis Franklin Fellowship as an ever-living memorial to his services to

[1] Attention is called to the series of articles by Fernelius and Johnson on "Liquid Ammonia as a Solvent," THIS JOURNAL, **5**, 664–70; 828–35 (1928).

[2] "Edward Curtis Franklin—A Scholar and a Gentleman," W. A. White, *Ind. Eng. Chem.*, **19**, 1927–98 (Nov., 1927).

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Stanford University one of the enthusiastic supporters of the plan said, "We provide memorials of many kinds to many men for many forms of public service. But we all too rarely express in concrete form the appreciation of our debt to such men as Franklin."

We endorse this project most heartily as a graceful and appropriate acknowledgment of the debt which the science of chemistry and the Stanford University owe to Franklin, the scientist, the teacher, and the man.

Conference on Pandemic Chemistry

IT IS impossible to generalize briefly concerning the conference on pandemic chemistry held at the recent meeting of the American Chemical Society at Swampscott, Massachusetts. For if there was any one aspect of the symposium especially calculated to impress the observer it was the number and variety of interpretations placed upon the subject of discussion. Yet despite the wide divergence in the mediums of instruction advocated, the methods of presentation employed, and even, to a certain extent, in the immediate objectives sought, certain common factors were discernible.

"Pandemic" chemistry is only our old friend "cultural" chemistry masquerading under a newer and perhaps catchier title. It involves a recognition of the fact that the terms "elementary" chemistry and "beginning" chemistry, so often interchangeably used, are not strictly synonymous, and that the former is far too frequently misused. Otherwise speaking, it is based upon a perception of the fact that professional training arbitrarily arrested in its earlier stages does not inevitably fulfil the cultural ideal.

Perhaps this point will justify some amplification. Wherein do the beginning professional courses fall short? Often they are culturally deficient in that they are "elementary" only by limitation. They deal largely with "elements" or fundamentals, but they cover only a fraction of the fundamentals of the science. They present a small fragment of the picture in some detail, rather than the bold outlines of the picture as a whole. Succeeding courses are relied upon to round out the sketch by extension of area rather than by amplification of detail. It is true that beginning professional chemistry *need* not be taught in this fashion, and that it is not exclusively so taught. The fact remains that it *has* usually been taught in this way.

But there is another more essential difference between the professional course and the cultural course. The prospective chemist must acquire certain working tools and, in the process, undergo certain drills of no

merit in themselves—necessary only as a means toward an end. The general student has no need to acquire these tools. It is sufficient if their workings are explained to him. Drill in their application is not only highly distasteful but useless to him.

Finally, the cultural course requires a more humanistic method of treatment than is essential (though perhaps not more so than is desirable) in the professional course. The teacher must inject more intrinsic interest into the subject-matter and into the presentation of the cultural course than is required of him in the professional course. For the general student is not fortified against dullness by the secondary motives which sustain the professional student. The cultural course must stand upon its own merits rather than upon the promise of future salary checks or scientific fame.

Without involving ourselves in an academic discussion of the meaning of culture or an extended examination of objectives, we believe we may acceptably say that a course in chemistry, to have cultural significance, should give students:

(1) Some idea of the present status of the science and of the more important stages through which it has advanced in arriving at its present state of development;

(2) An acquaintance with the more important facts and principles on which the science is based, and a qualitative understanding of its methods;

(3) An intelligent appreciation of its philosophic and material contributions to modern civilization;

(4) The ability to follow understandingly and with interest non-technical accounts of contemporary chemical progress.

Furthermore, it should serve as a pretext or as a medium for the exposition of the scientific method of thinking and, in so far as is possible, for the inculcation of the scientific attitude of mind.

Assuming these objectives to constitute a more or less common point of departure, the wide variety in the courses arrived at may be attributed to a number of factors. In the first place it is evident that not all teachers consider these five aims as of equal importance. Some instructors magnify one or more of them out of all proportion to the remainder. The selection of subject-matter and the method of attack are roughly determined at this point. The desirability of maintaining interest, not only as an aid to immediate learning but as one of the permanent residuals of the course, further influences both the selection of subject-matter and the manner of presentation. Here the teacher's decisions are determined or largely conditioned by his personal tastes. He is naturally inclined to feel that phases of the subject which are of absorbing interest to him cannot fail to interest others. And in so thinking he is

not misguided, for although his mind and interests may not be typical of those represented by the class before him, the odds are good that he can teach most interestingly those things which interest him most, and that the mode of presentation most natural to him is that which he can employ most effectively.

While individual differences in teachers account for a wide diversity in ideas as to what should constitute the ideal course in pandemic chemistry, modifications do not cease here. Often the pressure of external circumstances causes the course taught to differ considerably from the course which the teacher considers ideal. The problem is comparatively simplified if the teacher can deal with a group or groups which are homogeneous as to previous training and future prospects. Where it is impossible to so group students, we believe that the best solution lies in a compromise based on the "minimum essentials" recommended by the Committee of Chemical Education of the American Chemical Society.[3] The topics listed as essential by the committee are sufficient, if thoroughly taught, to set the conscience of the teacher at rest concerning his duty to those who may follow him, yet they are limited enough to permit him much leeway in shaping the course to accord more closely with local requirements and his own cultural ideals.

The recognition of individual differences in capacity and previous training involves increased teaching labor, yet it can by no means be neglected by any conscientious and progressive teacher. Special assignments in the way of chemical projects and reports on outside reading have been successfully employed by many instructors. Here it seems that the prize essay contest of the American Chemical Society should prove useful as an incentive to better or more advanced students.

On the whole, the outlook is decidedly encouraging. There is evidently a very lively interest in a phase of chemical education which has long cried out for attention. Most of the courses described or suggested at the symposium were good. The lack of uniformity among them need cause no alarm. On the contrary, it is a very healthy sign in that it indicates a tendency on the part of instructors generally to mould their courses in such fashion as to take full advantage of any peculiar individual assets they may possess and with a view to meeting the particular circumstances which confront them. If any word of caution need be uttered it is to the effect that we eschew extremes and avoid making a fad out of what should be a normal and rational development of one important phase of chemical education.

[3] THIS JOURNAL, **5**, 640–56 (May, 1927). Reprints may be obtained free of charge from the editorial office so long as the supply lasts.

BLASTING EXPLOSIVES

B. A. GILLIE, EASTERN LABORATORY, E. I. DU PONT DE NEMOURS & COMPANY, GIBBSTOWN, N. J.

Thoughts of war or anarchists are brought to the mind of the average individual by the mention of explosives. As a matter of fact, over ninety-eight per cent of the explosives manufactured in this country during peace times are used in peaceful pursuits, and approximately five hundred million pounds are made annually.

Explosives are of two classes, low and high. Black powder and smokeless powder are the best known of the low explosives. Their action amounts to a rapid burning, the speed of the burning depending upon the degree to which they are confined. An average burning speed or velocity for confined black powder is 500 feet or one-tenth of a mile per second. High explosives, of which TNT (trinitrotoluol) and dynamite are the best known examples, are very much more rapid in their action, their energy being liberated almost instantaneously. Certain types of dynamite (the cartridges being placed end to end) will detonate at a rate of four miles per second. Admitting that God made light and radio waves and that man simply discovered their existence, high explosives are the fastest things made by man.

Black powder is the oldest type of blasting explosive and is made much the same as it was a hundred years ago. It consists of approximately 75% sodium nitrate, 15% charcoal, and 10% sulfur. It is manufactured by thoroughly incorporating the ingredients under heavy iron wheels. The incorporated powder is then pressed into cakes by a hydraulic ram, and these cakes are broken into grains by passing them through a series of rolls called a Corning mill. After "sizing" the grains by screening, the so-called "green grain" is tumbled in a large glaze barrel. The friction of the grains rolling over one another produces heat which dries the powder, and a glaze, which makes the powder more resistant to atmospheric moisture, is obtained by the addition of a small quantity of graphite. The powder is then packed in cylindrical sheet-iron cans.

Black or blasting powder is made in only one strength, but its speed of burning is varied somewhat by varying the size of the grains. Its effectiveness is destroyed by water and hence it cannot be used in so-called wet work. Upon exploding, it gives off relatively large quantities of smoke and noxious gas so that it is not adapted for underground work excepting in cases where small quantities are shot and where ventilation is good. It is not very strong (compared to dynamite) and is bulky, so it cannot be used for blasting hard rock. Because of its heaving action, black powder is admittedly the best "coal getter" where lump coal is desired. However, it should not be used in gaseous or dusty coal mines, because it explodes

with a lengthy flame of extended duration which is likely to result in a mine explosion.

Black powder in pellet form was introduced in this country about three years ago. The composition is practically the same but the powder is compressed into cylinders, usually two inches long and one and one-quarter inches or larger in diameter. The pellets are wrapped in paper, four to a cartridge, the cartridges being dipped in paraffin and packed in wooden cases. Pellet powder overcomes many of the objections to grain powder and is safer to handle.

Black powder was the chief blasting explosive until Nobel's discovery of dynamite made possible the use of nitroglycerin which was discovered by Ascanio Sobrero in 1846. Since then, dynamite has gradually replaced black powder until today it is the foremost commercial blasting agent. Dynamite, as discovered by Nobel, consisted of nitroglycerin absorbed in kieselguhr. Although some college textbooks still teach that dynamite is nitroglycerin absorbed in kieselguhr, so-called *guhr dynamite* has not been used for many years.

To the layman, dynamite is dynamite, or possibly he may have heard that it is made in more than one strength. As a matter of fact, some manufacturers produce over a hundred different grades, and approximately three hundred and seventy million pounds are sold annually in this country.

Guhr dynamite consisted of 75% nitroglycerin and 25% kieselguhr. The latter being inert, not only does not enter into the reaction of detonation, but actually detracts from the strength of the nitroglycerin. By substituting a combustible absorbent such as wood pulp for the guhr and adding sodium nitrate to supply the oxygen necessary for the combustion of the wood pulp, we have our present-day *straight dynamite.* A dynamite containing 40% nitroglycerin (or its equivalent in other explosive material) is said to be 40% strength; 60% nitroglycerin of 60% strength, etc. This is the basis of the method of expressing the strength of dynamite.

Straight dynamite is manufactured in strengths from 15 to 60%, and under the name of "Judson" powder as low as 5%. The *straight dynamites* are very shattering (of high velocity), their action being quite the opposite of black powder in this respect. They are relatively sensitive to shock and friction, and, because of the large percentage of combustible material required to absorb the liquid nitroglycerin, the higher strengths cannot be properly balanced as regards their oxygen content, hence, they give off relatively large amounts of carbon monoxide upon detonation.

Ammonium nitrate is approximately 70% as strong as nitroglycerin. By replacing about half of the nitroglycerin in *straight dynamites* with an equivalent amount of ammonium nitrate, on a strength basis, the so-called ammonia grades are obtained. These grades, which are made in the various strengths, are safer to handle and more economical than *straight*

dynamite. They are as strong in gas pressure as the equivalent *straight powders*, but are lower in velocity and hence less shattering. They contain less carbon and are capable of being balanced as to their oxygen content so that they give off less objectionable fumes upon detonation. *Ammonium nitrate dynamites* are very popular, some seventy million pounds of this compound being used annually in the manufacture of explosives.

The *straight dynamite* grades are usually made at such a density as to give 100 to 110 cartridges, $1^1/_4$" diameter and 8" long, to a 50-pound case. Until recent years, the ammonia dynamites were made of the same density as the *straights*, but grades are now being manufactured with as many as 185 or more cartridges to the case of 50 pounds. By variation in density, variations in the distribution of strength when shooting in the bore-hole are obtained.

Special types of dynamite are manufactured for use in gaseous and dusty coal mines which are known as *permissible explosives*, a *permissible explosive* being one which has passed certain tests prescribed by the United States Bureau of Mines. The explosion temperature of dynamite is around 2600°C., whereas the explosion temperature of the *permissible dynamites* is in the neighborhood of a thousand degrees below this. Ammonium nitrate is the base of the most popular types of so-called *permissibles*. By using only sufficient nitroglycerin to properly sensitize the ammonium nitrate, and by adding various cooling agents, such as sodium chloride, explosives are made which detonate at relatively low temperatures and with a short flame of brief duration. A typical formula for a *permissible explosive* is as follows: nitroglycerin, 10%; ammonium nitrate, 70%; wood pulp, 10%; sodium chloride, 10%. *Permissible explosives*, and there are about 140 of them listed at present, are safe to employ in gaseous and dusty mines when used in the quantity prescribed by the U. S. Bureau of Mines; *i. e.*, not over one and one-half pounds to a blast.

Nobel discovered that if nitroglycerin and nitrocotton are mixed together (92% NG to 8% NC), a rubbery substance is formed which is called *blasting gelatin*. This is the strongest commercial explosive manufactured, being stronger than either nitroglycerin or nitrocotton alone. The reason for this is that explosives are strongest when they are deficient in oxygen for complete combustion by 10 to 20% of the weight of the explosive, and the nearer they approach this oxygen balance, the stronger they are. *Blasting gelatin* (also called solid nitroglycerin) is little used except for "shooting" oil wells.

By using relatively small percentages of nitrocotton colloided with nitroglycerin, a mucilaginous substance is formed, which when mixed with nitrate of soda, wood pulp, starch, and other combustible ingredients makes *gelatin dynamite*, the most popular of all commercial explosives.

Gelatin dynamites are made in strengths from 20 to 90%. They have

several distinct advantages over non-gelatinized grades. Because of their consistency, they are not penetrated and hence are not desensitized by water even when subjected to 15 pounds pressure for several days. They are denser than other types (usually running 85 to 95 cartridges per 50 lb.) and so their strength may be concentrated for heavy burdens. They detonate at high velocity when confined. Being plastic, they can be made to stick in holes drilled upward.

The liquid nitroglycerin is held as a colloid by nitrocotton so it is unnecessary to use high percentages of carbonaceous absorbents as in the non-gelatinous grades. Because of this, and the use of specially designed cartridge paper, gelatin, in strengths up to 60%, can be so perfectly designed as to give off almost no noxious gas upon detonation. Hence gelatins are well adapted to all underground tunneling and mining.

By the partial replacement of nitroglycerin with ammonium nitrate, ammonia or special gelatins are produced. Because of economy, these are more popular than the *straight gelatins*. It is only within recent years, however, that the chemist has learned to make *ammonia gelatins* which may be stored for an extended period of time without leaking, that is, exuding nitroglycerin.

In recent years, *permissible gelatins* have been developed which are well adapted for rock blasting in coal mines, and in some seams are used for blasting the coal itself.

Nitroglycerin freezes at 54°F., and when frozen is very dangerous. Frozen dynamite is less sensitive to detonation by the usual means than when not frozen, but is more sensitive to shock and friction. Consequently, some cartridges may fail at the time of the blast and later explode when hit with a pick or shovel. The thawing of dynamite by careless or untrained workers is also very dangerous, especially when attempted by means of open fire or in the oven of a cook stove. Many fatal accidents have occurred in handling and thawing frozen dynamite but, thanks to the chemist, those days are in the past, for practically every pound of dynamite produced today will resist freezing at any temperature that may obtain in the district in which it is to be used.

The rendering of nitroglycerin resistant to low temperatures, or low freezing as it is called, is accomplished by adding freezing-point depressants such as dinitrotoluol, trinitrotoluol, nitrated sugar, etc., or by the addition of low-freezing liquid explosives such as tetranitrodiglycerin or ethylene glycol dinitrate. The latter has been used in large quantities for several years and has been found to be the most satisfactory compound for the purpose.

Nitrostarch is used to a small extent in place of nitroglycerin in blasting explosives. Practically the only advantage of nitrostarch is that its handling does not cause headache as is the case with nitroglycerin. On the other hand, nitrostarch powders have disadvantages which limit their utility.

The successful manufacture of dynamite requires detailed technical knowledge and experience and unceasing vigilance, for explosives are not to be trifled with or treated in a haphazard manner.

Nitroglycerin is made by slowly adding refined glycerin to brine-cooled mixed nitric and sulfuric acids, with constant agitation. After it is separated from the spent acid and neutralized, it is weighed into a lead-lined, rubber-tired cart or "buggy" and taken to the dynamite mixing house. The non-explosive ingredients, which are carefully made and tested to insure uniformity within strict specifications, are weighed in a building called a "dope" house. The explosive and non-explosive ingredients are brought together and incorporated in a mixing bowl, a picture of which is shown (see Figure 1). The bowl and the wheels are lined with a rubber composition.

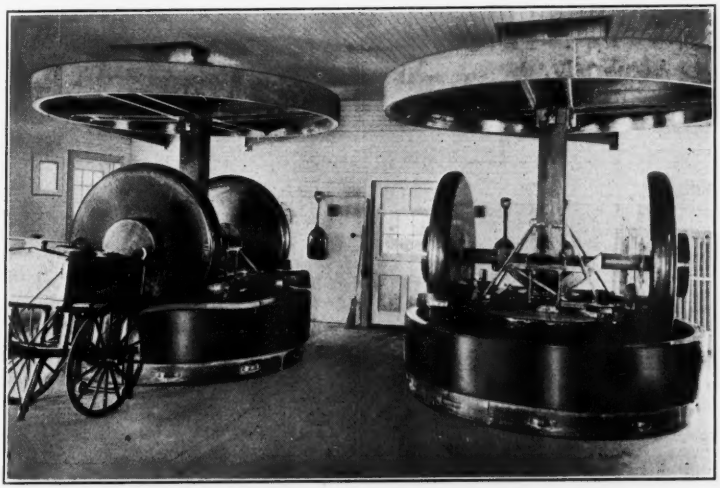


FIGURE 1.—DYNAMITE MIXING HOUSE. NITROGLYCERIN BUGGY AT LEFT

After incorporation, the dynamite is shoveled out of the bowl, with wooden shovels, into wooden carriers and taken to the next house to be cartridged by an almost human tamping machine. The cartridged dynamite is then conveyed to another house where it is dipped in melted paraffin for water-proofing and packed in wooden cases for shipment.

A different type of mixing bowl, which is water-jacketed for heating, is used for mixing *gelatin dynamite*. The cartridging machine is also of a different type, the gelatin being extruded into the paper shells by means of a worm.

Most of the explosive manufacturers maintain laboratories for the development of new and the improvement of existing grades of dynamite, and the testing of dynamite in these laboratories is a science in itself. In the description of the various types of dynamite, such properties as sensitiveness, strength, velocity, or detonation and "safety" or permissibility were mentioned. A brief description of how these properties are measured might be of interest.

There are several kinds of "sensitiveness" which have no definite relation to one another. All commercial explosives sold by reliable manufacturers are sufficiently insensitive to friction and impact to permit handling with safety. The sensitiveness usually referred to by users of explosives is "sensitiveness to influence" or "propagating distance" and is expressed as the distance at which a half cartridge can be detonated by the explosion of the other half, the cut ends pointing toward one another. A certain propagating distance is desirable to insure propagation from one cartridge to another but this need not be great except in ditch blasting where the cartridges are put into the ground twelve to eighteen inches apart and only one cartridge is fired directly, the remainder of the line detonating from shock.

The strength of dynamite is usually measured by a ballistic pendulum of which there are two well-known types. The Bureau of Mines type consists of a sixteen-ton cannon suspended by steel rods from knife edges. The dynamite charge is fired from a smaller cannon which is on a track and so placed that the gases from the detonation expand into the bore of the large cannon. The deflection of the large cannon is measured by a vernier scale. One-half pound of 40% *straight dynamite* is shot to determine the unit swing. The weight of the charge of the powder under test, which gives the same swing, is termed the Unit Deflective Charge (U. D. C.) of the dynamite.

The mortar shown in Figure 2 consists of a cannon weighing 600 pounds hung from knife edges by aluminum hangers. Ten gram charges of the explosive are fired in the suspended cannon, the charge being confined by a shot which is shown on the floor in front of the mortar. The shot is fired into a pit filled with sand and burlap bags. The deflection of the pendulum is measured by a pointer on an arc. The strength of the dynamite under test is expressed in terms of "TNT value," which is defined as the number of grams of TNT which causes the same deflection as 10 grams of the explosive. By establishing curves for the strength of *straight dynamites* of various percentages, the per cent strength of the dynamite under test is determined from the U. D. C. or TNT value, as the case may be.

The velocity of detonation of dynamite is determined by either of two methods. The Mettegang recorder, which is a special type of electric chronograph, measures the time elapsed between the breaking of two wires,

two meters apart, by the detonation wave traveling along a file of cartridges placed end to end.

The Dautriche method is a unique indirect test by which a comparison is made between the dynamite and Cordeau fuse which has been previously

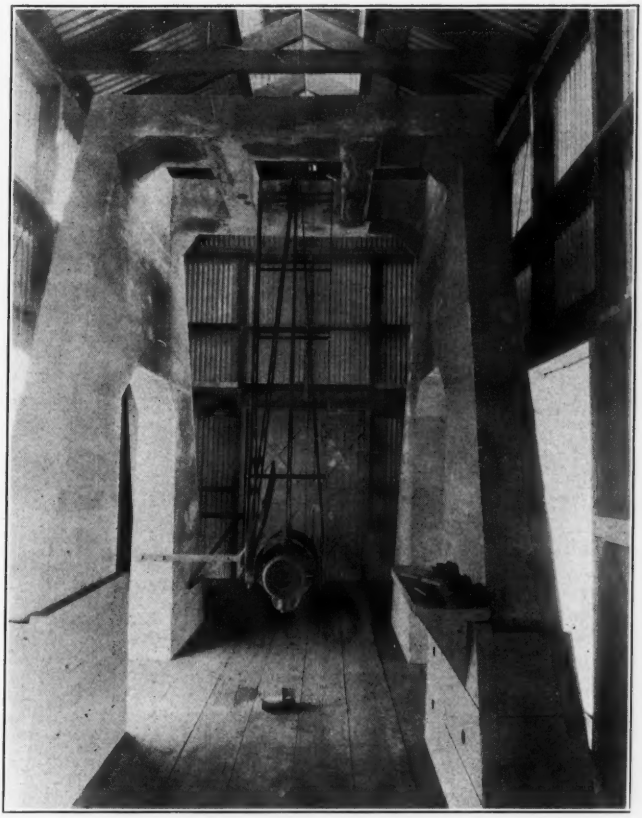


FIGURE 2.—BALLISTIC PENDULUM IN WHICH HIGH EXPLOSIVES ARE TESTED FOR STRENGTH

calibrated. Cordeau fuse comprises a lead tube about one-quarter inch in diameter with a core of TNT through its center, and detonates at a rate of about 17,000 feet per second.

The illustration (Figure 3) shows the layout of the shot. The center of the length of Cordeau is placed at a mark, *A*, on a lead strip. The detonation of the dynamite is initiated at *D*. The detonation wave travels

through the dynamite file and through the Cordeau leading from the dynamite. The two waves running along the Cordeau meet at some point on the lead as, for example, *E*, and leave a mark. Knowing the rate of detonation of the Cordeau, the distance between the Cordeau ends and the distance from *A* to *E*, the velocity of the wave through the dynamite is easily calculated.

The principal tests made in determining the "safety" or permissibility of dynamite for use in gaseous or dusty coal mines are carried out in a gallery, an illustration of which is shown (Figure 4). The gallery

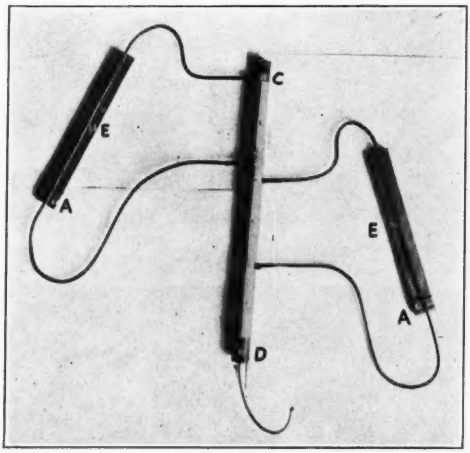


FIGURE 3.—ARRANGEMENT USED IN THE DAUTRICHE TEST FOR THE DETERMINATION OF THE VELOCITY OF DETONATION OF HIGH EXPLOSIVES

consists of a steel tube about six feet in diameter and eighty feet long. An eighteen-foot section at one end of the gallery is sealed off by a paper diaphragm. This section is filled with an explosive gas of definite concentration, or coal dust, or a mixture of gas and dust, and the explosive is fired from a cannon into the explosive mixture through a hole in the end of the gallery. The largest quantity of explosive which can be fired into the gallery without causing ignition of the gas or dust gives a measure of the "safety" of the powder. The photograph shows the gallery after a coal dust explosion.

Many other tests, too numerous for description here, are made in determining such properties as water resistance, resistance to freezing, inflammability, quantity and kind of fumes given off upon detonation, storage keeping qualities, sensitiveness to friction and impact, etc.

In blasting, the explosion must be initiated. Black powder, which is a deflagrating explosive, is usually fired by means of a flame from a fuse or a squib, of which there are various types. Dynamite and other high ex-

FIGURE 4.—GALLERY IN WHICH COAL MINE EXPLOSIVES ARE TESTED FOR PERMISSIBILITY

plosives require an intermediate agent known as a detonator or blasting cap.

Blasting caps contain high explosives known as primary detonators which have the property of detonating (under certain conditions) when brought in contact with a flame. Mercury fulminate is the most common primary detonator although there are many others.

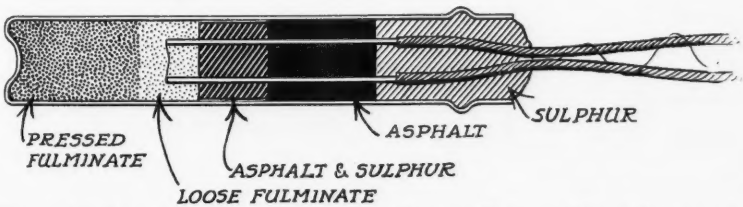


FIGURE 5.—SHOWING THE CONSTRUCTION OF AN ELECTRIC BLASTING CAP OR DETONATOR

The simplest type of blasting cap consists of a copper shell about a quarter inch in diameter and an inch and a half long, and closed at one end, into which a gram of fulminate of mercury is pressed. This type of cap is used with fuse, and detonates when the spit of flame from the fuse comes in

contact with the fulminate. Such a cap, with fuse, is shown at *D* in Figure 3. Electric blasting caps are similar to ordinary blasting caps except that they contain in addition a loose explosive charge in which is embedded a fine platinum wire connecting the ends of a pair of wires leading to the outside of the cap (see Figure 5). This fine wire becomes white hot and explodes the cap when a current of electricity from a blasting box, battery, or power line is passed through it. Some manufacturers use a match head for ignition instead of the loose explosive charge. The match head, however, is ignited by a wire heated by an electric current.

Caps and electric caps are also made with a booster charge at the closed end; that is, pressed under the fulminate load. Tetryl (tetranitromethylaniline) is one of the best secondary or booster explosives and makes a much stronger cap than fulminate alone.

FIGURE 6.—DRILLING A BORE HOLE FOR A BLAST IN A COAL MINE

Cordeau fuse, mentioned above, is also used for detonating dynamite, and for connecting charges in adjacent bore-holes. It has the advantage of detonating the dynamite along its entire length, and of increasing the velocity of dynamite through which it is placed, provided that the velocity of the Cordeau is higher than that of the explosive. The Cordeau, however, must be detonated by means of a blasting cap.

Many industries claim to be the keystone in the arch of our present civilization. When it is considered that all the iron and steel for our industrial plants, sky-scrapers, ocean liners, battleships, and automobiles, all the coal for power and heating, all the copper for electrical machines and telephone lines, all the cement for roads and foundations; in fact, a very large part of the raw materials that occur in the earth are taken therefrom with

the aid of explosives, and could not be taken from the earth by any other means at anywhere near the rate necessary for present needs: when all this is considered, it may be justly claimed that the explosives industry is the foundation stone of the same arch.

The public seems to be imbued with the idea that explosives (especially dynamite) will go off if dropped from any height on anything harder than a bed, and that dynamite may "take a notion" to explode at almost any inconvenient time. It is foolhardy to say that explosives are not dangerous for they are designed to explode and should be handled with respect, and

FIGURE 7.—A QUARRY BLAST

only by those who have the knowledge or have been instructed as to their proper use. The degree of exaggeration of the usual opinion as to their danger may be realized, however, by giving thought to the following quotation from the last "Report of the Chief Inspector of the Bureau of Safe Transportation of Explosives and Other Dangerous Articles," to the effect that "during 1927, transportation was furnished for all explosives moved in the United States and Canada, including a total of about 500 million pounds of dangerous explosives without any loss of life or injury to life and with a total money loss of $45." This is a record of which to be proud and is only accomplished by knowledge, strict regulation, and unceasing vigilance and care. Needless to say, reliable manufacturers are no less careful and constantly "lean over backward" in the interests of "safety first."

CONTRIBUTIONS OF CHEMISTRY TO INDUSTRY. PART I*

WALTER A. SCHMIDT, WESTERN PRECIPITATION CO., LOS ANGELES, CALIFORNIA

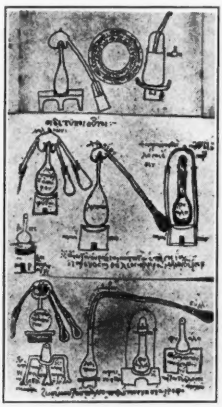
The history of the primitive peoples is often divided into major periods, such as the stone age, the bronze age, etc., and some of our popular writers have classified the century which is just behind us as the mechanical age, for during this period civilized humanity succeeded in shifting its labors and toil to inanimate power. During this period mechanical equipment of every conceivable kind was developed to perform the work which had previously been done by human hands. When we look back over the last hundred years and compare our present-day lives with those of our grandfathers, we cannot help but be impressed by the progress that has been made. The old platitudes of "industrial revolution" and of "revolution of human thought" have in some measure become meaningless to us because we fail to recognize the tremendous changes which have come about, being so engrossed in our daily activities and enjoying, without particular consciousness, the various blessings which this progress in the mechanical arts has made possible of enjoyment.

The same popular writers are now saying that we are entering upon the chemical age, asserting that the major stride in mechanicalizing human activities has been effected and that the next big change will result from our learning how to produce in factories the raw materials for which we have heretofore depended on agriculture, or which we drew from the bountiful supply of nature. And, it is said, that even more important will be the change resulting from the production of substances and materials which heretofore even nature could not produce. It is common knowledge that considerable progress has already been made in this direction and it will be the purpose of this discussion to outline very briefly some of the ground which has been covered. It would be a rash man indeed who would venture a guess as to what the next hundred years will bring about, when one contemplates the changes which have been wrought in the past hundred years by the exercise of diligent research and human ingenuity in the mechanical arts and sciences, for it must not be forgotten that, while mechanical developments largely eliminated labor and toil, future chemical developments will bring to us materials and products which have never even been dreamt of, and each of these new products is bound to influence our mode of living, our habits, and our outlook on life. This change undoubtedly will be even deeper and more far reaching than the change which

* Paper delivered before the Engineers Club of Los Angeles, California, May 17, 1928. This paper was prepared for presentation to the Engineers Club of Los Angeles without thought of publication. The paper contains a considerable number of verbatim quotations from various reference books, but as these references were not marked in the original manuscript, their identity has been lost, for which the author offers an apology.

followed the development of the science of electricity, which made possible the harnessing of an invisible power to accomplish results which previously would not have been considered possible by even the most fantastic dreamers.

Although chemistry, as a science, is essentially a thing of the present and the future, it must be remembered that its roots stretch back through many centuries. It is quite evident that in the early civilizations, many sages speculated on the structure of matter, and craftsmen actually achieved considerable progress in making products and materials which were not found, as such, on the surface of the earth. It is only necessary to call attention to the wonderful development of glasses, porcelains, and enamels in ancient Egypt, to show that thousands of years ago men were hard at work to accomplish the same ends which modern chemical industry aims to achieve; namely, the production of artificial useful materials. However, there is one distinct difference between the work of the ancient chemical craftsman and the work of the modern industrial chemist. The former worked entirely by haphazard methods, without any fundamental knowledge of what he was doing, while the modern industrial chemist handles atoms and molecules in a manner comparable to the way in which the craftsmen and the artists of old handled visible substances. The ancient chemical craftsman mixed various materials, subjected these mixtures to heat or to the action of solvents, and breathlessly awaited the outcome of his experiment, expecting that the result would be some mysterious product possessing wonderful properties of value for good and for evil. Nevertheless, a large number of useful results were achieved, and in the very earliest civilizations we find such products as glass, porcelain, and enamels;



Ancient Apparatus—Water Bath, etc., from Greek Manuscript of St. Mark

Ancient distillation—of medicinal herbs for making medicinal waters—shows women gathering herbs also.

metals such as copper, iron, tin, and mercury; alloys such as bronze; fermentation products such as wine and vinegar; and distillation products such as alcohol. The Chinese developed gunpowder, and soap was also developed at a very early date.

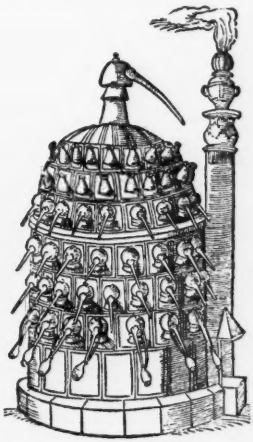
In the absence of a proper understanding of the structure of matter, it is only natural that weird and fantastic theories should have gained a foothold. Whereas the early work chiefly led to the development of useful formulas, the Middle Ages brought forth a hopelessly bewildering philosophy, which in turn carried a tremendous number of people into the so-called art of alchemy. It must not be forgotten that, during this period, the reigning school of thought was an elaboration of the teachings which had been handed down from the old Greek civilization, and such scientific thought as did exist was based on the doctrines of Aristotle, who is given the credit of being the forerunner of modern science in as much as he based his philosophy on observed facts rather than upon mental abstractions. Aristotle, however, was not scientific in the modern sense, in that he was the exponent of the Greek deductive philosophy. While we must give Aristotle due credit as the discoverer of the laws of deductive reasoning, he nevertheless had no idea of the inductive methods of arriving at general laws which are finally established by experimental verification. While he was anxious to make fact the basis of every theory, his great want was experiment. He made many observations of much accuracy in natural history, but the art of precise experimentation had not been developed, nor had any exact quantitative record of observations been made. Being thus destitute of facts, he could only in a slight degree modify the childlike views of the Greeks, and had to rest content with such unverified hypotheses as seemed to him best to cohere and to explain the natural things. Like others before him, he argued from general principles to particular instances, instead of founding his general principles upon experimental particulars. During the Middle Ages, Aristotle's logical system dominated all thought, but it was apt to be used as a mere device for developing conclusions from given premises, and this led to the establishment of many wild and fantastic schools of thought, among which one of the most peculiar was that of alchemy.

In the second century A.D., there appeared a number of alchemistic writings which at a later date were attributed to the authorship of Hermes Trismegistus—the name of Hermes probably accounting for the expression "Hermetic" art. About 400 A.D., the doctrine of transmutation of metals began to assume prominence, and the Greek orator, Themistus Euphrades, spoke of the transmutation of copper into silver and gold as being a universally accepted fact. About the end of the eighth century, there came out of Arabia the alchemist, Abu Geber, who claimed to have made the "elixir" or powder of transmutation, and, according to legend, he was the author of

many alchemistic writings which later assumed great prominence. There is good reason to believe, however, that the works, upon which Geber's reputation rested in the Middle Ages, were not written by him, but were forgeries of the thirteenth century. According to these writings, Geber was acquainted with alum, green vitriol, saltpeter, sal ammoniac, aqua fortis and aqua regia, and for the use of all he gave directions. He extracted and purified his substances by the processes of distillation, sublimation, crystallization, and filtration. Oil of vitriol seems to have been known to him, and he apparently prepared mercuric oxide and corrosive sublimate.

After Geber, the study of alchemy became very widespread and the apostles thereof became so numerous that a recitation of their names would be tiresome. By the time of Paracelsus, in the early part of the sixteenth century, this school of thought had taken on such proportions that kings and princes were paying tribute to the alchemists in the hope that they would unearth the secret with which to replenish the depleted coffers of the various principalities. Likewise, men of wealth, who were losing the fire of youth, were parting with some of their fortunes in the hope that the elixir of life could be brought to them.

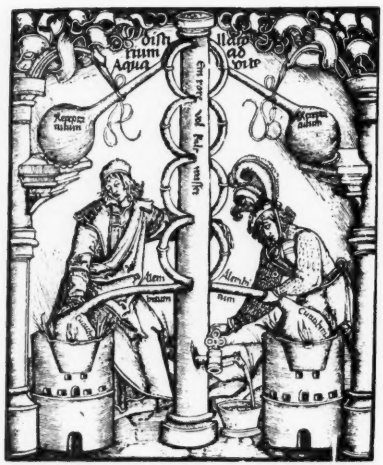
Alchemist's fireplace, A.D. 1618.



Distilling stove, A.D. 1586. Made of tile—was said to distil over 100 pounds of water in 24 hours.

Although this period brought forth many charlatans and quacks, it is unquestionably true that a large number of the alchemists were earnest students and sincere investigators moved by the same emotions which spur on the modern scientists in their researches. Making faulty observations, it was only natural that erroneous conclusions should be arrived at but,

after all, their theories were not as foolish as they appear on the surface. For example, iron was immersed in the waters from certain springs and the metal was transformed into copper. It was not recognized that these waters had seeped through copper-bearing ores and carried copper in solution, and it was not known that iron was more electro-positive than copper and displaced copper in solution. The alchemist was merely confronted with the fact that he put metallic iron into the water and that metallic copper appeared, whereas the metallic iron disappeared. Faced with this isolated fact, it was not a rash theory to assume that the iron was transformed into copper. And if iron could be transformed into copper, it should certainly be possible to transform base metals into gold. As lead and mercury were plentiful and cheap, while gold was scarce and valuable, it was only natural that these men should search for the means of transmuting these base metals rather than to prospect for new gold mines. Furthermore, alchemists had found that people suffering from certain ailments could be cured if they were treated with certain materials such as mercuric salts, and if one remedy could be effected, it was only natural to assume that other cures could also be effected, and that with the proper elixir of life, it should be possible to prevent death, and to extend the period of youth everlastingly. When we consider the amount of money which is spent today in beauty parlors and rejuvenating institutes, it is no wonder at all that endless effort was spent in finding the unknown elixir of life.



Distilling apparatus—fifteenth century.

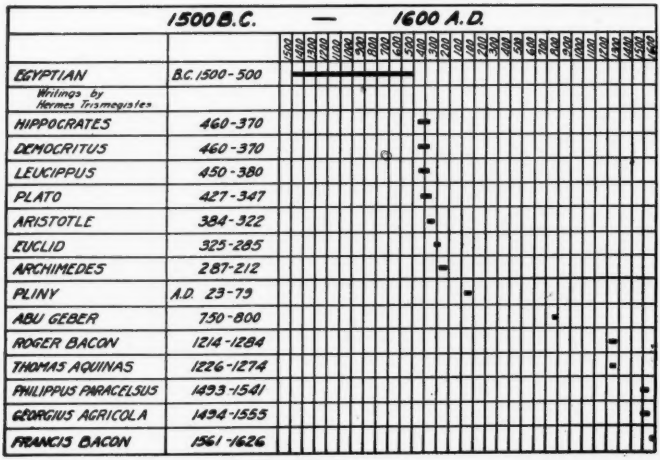
This all led to a strange set of doctrines, a description of which would take more time than is available in this discussion. It is possibly sufficient to say that the alchemists of the Middle Ages produced a remarkable trilogy. On the basis of the earlier idea of the division of the human body and the established doctrine of the Holy Trinity, they divided the material world into sulfur, mercury, and salt; the human world into body, mind, and spirit; and the divine world into Father, Son, and Holy Ghost. It must be remembered, however, that the sulfur, mercury, and salt of the alchemists were not the same as our present elements sulfur and mercury and the compound sodium chloride. They were more to be looked at as three principles. The sulfur of a metal represented its color, its combustibility,

its affinity and its hardness. The mercury of a metal represented its luster, volatility, fusibility, and malleability. The salt of a metal was merely the means of union between the mercury and the sulfur, just as the vital spirit in man unites soul and body. It was doubtless devised to impart a triple form to the idea, in conformity with the method of the theologians. Mercury, salt, and sulfur were not three matters, but one, derived from the "prima materia." The actual metals were given other associations, for example, gold corresponded to the sun; silver to the moon; mercury to the planet Mercury; copper to the planet Venus; iron to the planet Mars; tin to the planet Jupiter; and lead to the planet Saturn, and this brought forth the hopeless relationship between alchemy and astrology. The search for the secret of transmuting base metals into gold and the search for the "elixir" of life were later combined in the search for the so-called "Philosopher's Stone," with which all things could be accomplished.

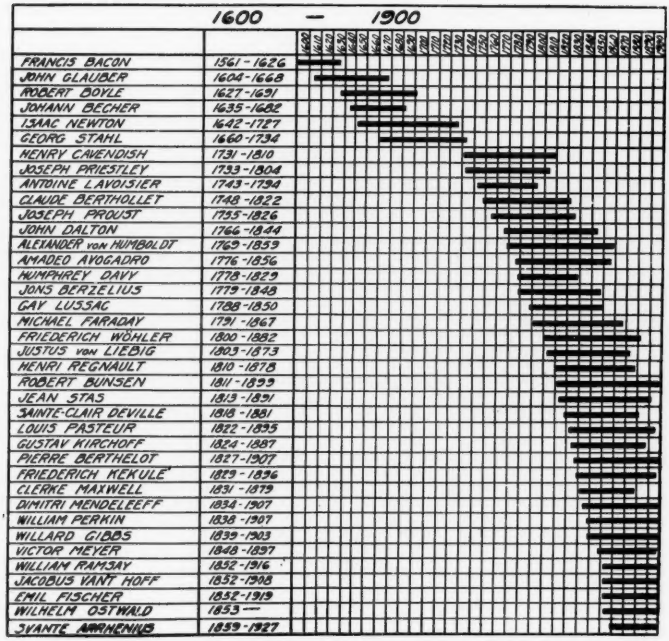
Union of sulfur, as King, and mercury, as Queen, to form the Philosopher's Stone (printed in 1550).

The large number of quacks and charlatans who exploited the innocent and unsuspecting public finally led to arrests, excommunications, and bans against the practice of alchemy, and this whole school of thought fell into decay. But out of all this work there was handed down a large amount of information in the form of isolated facts, which was useful for the early workers in chemistry, as we today define that science.

The aims and ambitions of our present-day research institutions are not so different from the aims and ambitions of the old alchemistic laboratories, as may appear at first sight. Our method of attacking problems is different and our terminology is different, but in the last analysis our hopes are more or less the same. I was astounded to find a quotation from Michael Faraday, quoted by Sir William Crookes, in an address before the British Association for the Advancement of Science. This quotation says, "To discover a new element is a fine thing, but if you could decompose elements,



Progress of Science: B.C. 1500 to A.D. 1600.



Progress of Chemistry: 1600 to 1900 A.D.

it would be a discovery indeed worth making. To decompose the metals, then to reform them, to change them from one to another, and to realize the once absurd notion of transmutation, are the problems now given to the chemists for solution." During the past few years we have had several recorded experiments by able investigators who have claimed that they have made small quantities of gold from mercury by subjecting the mercury under proper conditions to the action of electric discharges. We are all familiar with the fact that the atom is no longer considered as the ultimate division of matter, and we know that heavier elements, such as radium, are constantly decomposing with the formation of other elements, such as helium, and we also know that the properties of an element depend upon the number of electrons in the atom and their space orientation with respect to the central nucleus. If we but knew how to manipulate these electrons and the nucleus, the transmutation of one substance into another would be a simple matter. It is not at all inconceivable that in the future we will be able to accomplish this, and by doing so not only transmute one element into another, but at the same time tap the enormous supply of interatomic energy which today is unavailable to us.

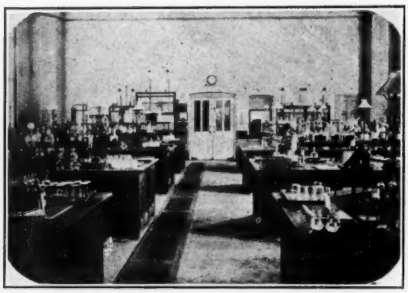
Pharmacal laboratory—1663.

Michael Faraday Washing Apparatus in Laboratory of Humphry Davy.

The transition of medieval alchemistic thought into modern chemistry was more or less simultaneous with the general intellectual awakening of Europe, much of which was due to the writings and teachings of Sir Francis Bacon, who is given the credit of being the father of inductive philosophy and the great master of inductive science. Bacon's philosophy in the last analysis taught that theories had to be based upon facts, which could be verified by experiment. Although Bacon himself made no contribution to

science, it is nevertheless true that he brought about a new mode of thinking, and in the wake of his teachings we find a large number of investigators making careful observations and accurate measurements, and thus laying the foundation for the various sciences which have since revolutionized human thought and human activities. Let us just recite a few of the high spots of this development in so far as chemistry is concerned and then contrast modern chemical industry with the industries of a century ago.

Chemical research laboratory of the Solvay Process Company.



A Government Laboratory—Customs Excise Department.

Robert Boyle, in the seventeenth century, established the fundamental laws on the behavior of gases. Becher and Stahl developed the phlogiston theory of combustion, which, although erroneous, brought forth a certain degree of order out of the chaos of previous misconceptions. At the same time, Newton laid the foundation for the mathematical interpretation of scientific observations, gave a clear definition of force and developed the laws of motion. In 1774, Priestley announced the discovery of oxygen. Cavendish studied the properties of hydrogen. Berthollet analyzed ammonia, produced numerous new compounds, and made the first attempt to grapple with the problems of chemical physics in dealing with the principles of chemical affinity and chemical equilibrium. Lavoisier, toward the close of the eighteenth century, overthrew the phlogiston theory. Proust developed the theory of multiple proportions in chemical reactions, and Dalton announced the atomic theory of the structure of matter. By the beginning of the nineteenth century, the road was open for progress in the science of chemistry. When we consider that this was only one hundred and twenty-five years ago, the thought of what has happened since then is somewhat overwhelming.

The researches of Gay-Lussac, Humphry Davy, Berzelius, and a host of

others, soon built up the structure of modern chemistry. The brilliant researches of Michael Faraday laid the foundation of electrochemistry. Simultaneously the other natural sciences were developing. Avogadro, Ohm, Henry, Helmholz, Clausius, and many others built up the science of physics; naturalists, such as Alexander von Humboldt and Darwin, by their keen observations broke the shackles of superstition regarding the structure of the earth and life on its surfaces; astronomers carried their researches into the heavens. The second half of the nineteenth century saw modern science in full swing on its march of glory. Clerke Maxwell made his marvelous mathematical calculations, Liebig laid the foundations of organic chemistry, Wöhler synthesized urea and thus broke down the theory that organic compounds contain a vital principle, Victor Meyer, Bunsen, Kirchoff, and Berthelot carried out their extensive investigations in organic and inorganic chemistry, Mendeléeff developed the periodic system for the elements. Kekulé announced the structure of the benzene ring, Willard Gibbs developed the theory of equilibria of heterogeneous substances, Perkin synthesized mauve and laid the foundation for the synthetic coal-tar dye industry. Emil Fischer unraveled the structure of sugar and produced sugar synthetically, Ramsay studied the rare gases. Arrhenius carried out his researches on electrolysis. Van't Hoff and Ostwald developed the theories of solutions and broadened the field of physical chemistry. Then came a new legion of workers who brought forth discovery after discovery until the vista into the structure of matter and its behavior has opened up before us and with this has come a completely new vision of the future of civilization.

The kaleidoscopic change of views which came about during the nineteenth century naturally met with tremendous opposition from the scholars of ancient lore, from the adherents to old philosophies and religion, and from all those who held to the culture of the past. It seemed to them perhaps as though the structure of civilization was being undermined with a materialistic philosophy which would bring havoc in its wake. A celebrated divine, president of one of our most reputable colleges of colonial days stated: "Chemists talk of their oxygen, hydrogen and nitrogen. Fools! fools! What do they know about it? After all it is nothing but matter." It is interesting to note that as late as a century ago, Charles Caldwell, eminent and distinguished in physical and natural sciences, declared that he disbelieved in chemistry, saying it was only a speculative science, a flight of fancy, and a lineal decendent of alchemy, maintaining it was hardly short of lunacy to contend, as many chemists did, that chemical and vital forces were identical. He said, "It will require stubborn facts to convince me that man with all his corporeal and intellectual attributes is nothing but a hydrophosphorated oxide of azote. I have never opposed microscopic or transcendental philosophy in the true sense of the term, but

it is chemical philosophy I have opposed—that mongrel nondescript branch of science—no, not science, but a blunderer's balderdash—which identifies man in functions with a German stove or a Belgian beer barrel." But in spite of all this, the science of chemistry progressed and suddenly man found that he could do things which theretofore had not been possible.

New Nitric Acid Process in Italy. Two Italian firms have recently worked out processes for obtaining concentrated nitric acid direct from the oxidation of synthetic ammonia, according to the Department of Commerce.

One process is a patent of the Ing. Fauser of the Montecatini and the concentrated nitric acid is being produced in the Meran and Novara plants of the Societa Italiana Ammonia of the Montecatini group. The 1927 production of concentrated nitric acid by this process is estimated at 12,000 tons in terms of 100 per cent acid, about three-fourths of which was obtained in the form of 50–55 per cent acid in the Montecatini plants.

The remainder was produced at the Bussi plant of the Societa Azogeno on the patents of Ing. Toniolo. The Novara and Montecatini plants have a yearly capacity of 10,000 tons of nitric acid at 48° Bé. and another plant is now being put up by the Societa Italiana Ammonia at Mass, which will have an annual capacity of 3000 tons. Ing. Toniolo produces 60–70 per cent acid and the Bussi plant is also making liquid nitrogen peroxide. This new industry will make Italy independent of foreign sources of supply of nitric acid.—*Chem. Markets*, **23**, 220 (Aug., 1928).

Will-o'-the-Wisp Studied by Germans. Two close-up observations of the will-o'-the-wisp, those weird and elusive flames that appear over marshy ground, have recently been put on record by German observers.

H. H. Sven, a German scientist, observed one night in November, 1927, near an iron mine in Bohemia upon a swampy tract of land, four small bluish phosphorescent flames. They were of the height of a candle flame and a diameter of about an inch and were constantly hopping up and down. Near them appeared a flame of about three feet in height of a yellowish green color and diameter of about a foot. Their light was sufficient to read the face of a watch and to make notes, but the flames had no heat when touched. After the phenomenon had lasted 15 minutes they went out.

In the vicinity are several springs with radioactive water. Upon returning to the place in the daytime Mr. Sven could find no trace of the source of the flames. He learned however that while will-o'-the-wisps appear to be independent of air temperature they are dependent upon air pressure; the higher the pressure the less the light.

W. Schulze, during the war an officer in the army, describes the following. In September, 1914, his batallion was withdrawn from the front-lines and had to recross the river Muerthe. During the afternoon artillery had also crossed. The route led through dense woods and had become impassible because of heavy rains. Schulze saw on both sides of the route, where a corduroy road had been attempted, pale greenish and yellowish thin flames shooting up and down from about 12 to 18 inches high. More accurate observations could not be made, but the flames were doubtless produced by the great pressure, caused by the passage of artillery, combined with heat and rain. Gases apparently streamed from the moist earth and caused the flames.—*Science Service*

BORON: ITS IMPORTANCE IN PLANT GROWTH

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It was once thought that the food material of plants consisted entirely of decayed animal and plant remains. Such an idea was probably based on the belief that organic matter could originate only from other organic matter. Centuries later van Helmont apparently proved, by an interesting experiment, that plants obtained all their food from water. He neglected, however, to take into consideration one very important source of such material, namely, the air. Carbon dioxide, which is essential for the production of carbohydrates, is a constituent of the air. Beginning with the year 1699, experimenters grew plants with their roots in rain or distilled water and in water containing small amounts of dissolved matter. This made it possible to control the chemicals in contact with plant roots. Liebig, the German chemist, made the bold announcement in 1840, that decayed organic matter was not necessary for plant growth, but that inorganic substances such as nitrogen, phosphate, and potassium were the essential food materials of plants. Since this epoch-making announcement many experiments have been conducted in which plants were grown in water cultures and much exact information has been obtained concerning the number and nature of chemical elements regarded essential for plant growth.

For years, plant physiologists had limited the essential nutrients of plants to the following ten elements: C, O, H, N, P, K, Ca, Mg, S, Fe. This idea had become so fixed that even recent text and reference books on agriculture emphasize this orthodox list of elements. Such elements as Si, Cl, and Na are sometimes included in special cases, but, generally speaking, the list of ten has remained intact for years. Actual analyses have shown that many other elements are found in plants, but their presence *per se* is no indication that they are indispensable. The natural supposition is that the presence of such elements as Cu and B in plants is detrimental to growth because of their toxicity even in small amounts. This, however, is not the case, for in recent years improved technic and the use of highly purified salts have clearly shown the necessity of Zn, Mn, B, and other elements for the normal growth and health of plants. These recent discoveries in plant nutrition are somewhat analogous to certain studies in animal physiology. The importance of minute quantities of iodine in the thyroid glands of animals may be cited as an example.

Bertrand[1,2] was one of the first to show that small quantities of manganese were essential to plant growth. Later, the importance of this element has

[1] G. Bertrand, "Sur l'intervention du manganèse dans les oxydations provoquées par la laccase," *Compt. Rend.*, **124**, 1032–5 (1897).

[2] G. Bertrand, "Sur l'action oxydante des sels manganeux et sur la constitution chimique des oxydases," *Compt. Rend.*, **124**, 1355–8 (1897).

been clearly demonstrated by McHargue.[3,4] To the original list of ten elements Mazé[5,6] had added Zn, Al, I. The indispensable nature of zinc and boron for higher green plants has been demonstrated by Sommer and Lipman[7] and Sommer.[8] Brenchley[9] has recently presented a most interesting and thorough review of the effects of Cu, Zn, As, B, and Mn on plant growth. Perhaps the most extensive studies on the rôle of boron are those of Warington[10] and Brenchley and Warington[11] with reference to the broad bean. Johnston and Dore[12,13] have just completed a series of experiments which clearly shows that boron is just as essential to the growth of the tomato plant as the elements of the original ten group. Sommer[14] has shown boron to be essential to corn, peas, sunflowers, vetch, barley, buckwheat, dahlias, lettuce, potatoes, millet, castor beans, sugar beets, kafir, sorghum, flax, mustard, and pumpkins. The importance of boron to the growth of the potato plant has also been shown by Johnston.[15] The interesting and fascinating phases of such studies are the extremely small quantities of elements involved and the rôle they play in plant growth. It is the purpose to present here some of the results obtained in these studies with boron and thereby show how extremely sensitive the plant is to almost infinitesimal changes in the chemical constitution of the solution surrounding its roots.

[3] J. S. McHargue, "The Rôle of Manganese in Plants," *Am. Chem. Soc.*, **44,** 1592–8 (1922).

[4] J. S. McHargue, "Manganese and Plant Growth," *Ind. Eng. Chem.*, **18,** 172–5 (1926).

[5] P. Mazé, "Influences respectives des éléments des la solution minérale sur le developpement du maïs," *Ann. Inst. Pasteur*, **28,** 21–68 (1914).

[6] P. Mazé, "Détermination des éléments minéraux rares necessaires au développement du maïs," *Compt. Rend. Acad. Sci.*, **160,** 211–4 (1915).

[7] A. L. Sommer and C. B. Lipman, "Evidence on the Indispensable Nature of Zinc and Boron for Higher Green Plants," *Plant Physiology*, **1,** 231–49 (1926).

[8] Anna L. Sommer, "Further Evidence of the Essential Nature of Zinc for the Growth of Higher Green Plants," *Plant Physiology*, **8,** 217–21 (1928).

[9] Winifred E. Brenchley, "Inorganic Plant Poisons and Stimulants," 2 ed., Cambridge Univ. Press, **1927.**

[10] Katherine Warington, "The Changes Induced in the Anatomical Structure of *Vicia Faba* by the Absence of Boron from the Nutrient Solution," *Ann. Bot.*, **40,** 27–42 (1926).

[11] Winifred E. Brenchley and Katherine Warington, "The Rôle of Boron in the Growth of Plants," *Ann. Bot.*, **41,** 167–87 (1927).

[12] Earl S. Johnston and W. H. Dore, "The Relation of Boron to the Growth of the Tomato Plant," *Science*, **67,** 324–5 (1928).

[13] Earl S. Johnston and W. H. Dore, "The Influence of Boron on the Chemical Composition and Growth of the Tomato Plant" (in press).

[14] A. L. Sommer, "The Search for Elements Essential in Only Small Amounts for Plant Growth," *Science*, **66,** 482–4 (1927).

[15] Earl S. Johnston, "Potato Plants Grown in Mineral Nutrient Media," *Soil Science* (in press).

The importance of boron to the tomato plant was discovered accidentally. While the writer was making a study of the relation of potassium to plant growth, he soon found it impossible to grow healthy tomato plants in water cultures usually employed in such work. Because of the importance of boron to certain other plants it was suggested that a little boric acid might improve the growth. This was tried. Enough boric acid was added to the regular nutrient solution to bring the concentration of boron to 0.55 part per million. One-half part of boron in a million parts of solution brought about a wonderful transformation in the plants. Representative plants from two groups are shown in Figure 1. The solutions in which these plants were grown were exactly alike with the exception of their boron content. One plant was grown in a boron deficient solution (left); the other in a similar nutrient solution to which 0.55 p. p. m. boron had been added as boric acid.

FIGURE 1.—Tomato plants grown in nutrient solutions; left, boron-deficient, right, similar solution, but containing 0.5 p. p. m. boron.

An experiment similar to the one just mentioned may be repeated very easily. Place a number of tomato seeds between layers of moist filter paper and cover with a bell jar. Stretch two layers of mosquito netting, separated by a piece of 5 mm. glass rod, over a dish of water. When the roots have grown to a length of 2 to 10 mm. carefully insert them into the meshes of the netting and later, when the seedlings become 2 to 3 cm. long, transfer them to the culture jars. Ordinary fruit jars of the "Mason" type are good for this purpose. Flat, paraffined cork stoppers which fit the jars may be used to support the plants, the roots first having been inserted through a hole in the stopper and held in place by a small piece of cotton.

A good plant nutrient solution for use in such studies may be made to have the following partial volume-molecular concentrations:

$Ca(NO_3)_2$	0.005
$MgSO_4$	0.002
KH_2PO_4	0.002
$MnSO_4$	0.0000178

In order to keep the plants green 1 cc. of a 0.5 per cent ferric tartrate solution per liter should be added daily while the plants are young. Care should be exercised not to contaminate the solutions or plant containers with boron. For this reason distilled water should be used in making up the solutions rather than tap water, and the plant containers should be made of substances free from boron. Avoid the use of pyrex vessels or glazed pottery.

It may be of interest to mention some observations made in connection with the use of glazed earthen-ware jars. These observations well illus-

FIGURE 2.—Potato plants grown in sand cultures treated with solutions deficient in boron (left) and with solutions containing 0.5 p. p. m. boron (right).

trate the importance of extremely minute quantities of boron. Several series of sand culture experiments dealing with the mineral nutrient requirement of the potato plant[16] were carried out over a number of years. New glazed earthen-ware jars were used. In the first two experiments the plants grew very well. No boron had intentionally been added to the nutrient solutions. In the later experiments, however, the terminal shoots died before the plants reached maturity. The poor growth in the later experiments had remained an unsolved problem until recent experiments with the tomato indicated the trouble to be a deficiency of boron in the nutrient solution. In the first two experiments the plants apparently

[16] Earl S. Johnston, "Growth of Potato Plants in Sand Cultures Treated with the 'Six Types' of Nutrient Solutions," Univ. of Maryland Agric. Expt. Sta., *Bull.*, **270**, (1924).

obtained enough boron from the glaze of the new jars. This theory was put to a test[15] by growing two sets of potato plants in the original jars, using the same general methods and similar solutions made up from the same lot of chemicals. Boron was added to the solutions used in watering

Courtesy of United States Department of Agriculture

FIGURE 3.—Tobacco plants grown in nutrient solutions deficient in boron (culture on right) and supplied with boron (culture on left).

one set of plants. At the end of eight weeks the difference in growth was very marked. Figure 2 shows the appearance of representative cultures of each group. Not only was top growth greatly improved by the addition of 0.55 p. p. m. boron to the culture solution, but the weight of new tubers formed was more than doubled.

One other interesting experiment may be mentioned. McMurtrey[17] noted a puzzling breakdown in the terminal bud of tobacco plants grown in water cultures. If, however, tap water instead of distilled water was used in making up the nutrient solutions it was found possible to grow the plants to maturity. Recent experiments with water cultures have clearly demonstrated that this peculiar symptom may be overcome by adding a trace of boron to the nutrient medium. The use of tap water illustrates the point that a slight contamination of boron greatly influenced the nature of the entire experiment. Although the amount of boron needed by these plants was exceedingly small it was nevertheless necessary. Tobacco plants grown in water cultures are shown in Figure 3. The culture on the left was supplied with a trace of boron (0.5 p. p. m.). The other culture was deficient in boron.

TABLE I

ANALYTICAL DATA OF TOMATO PLANTS GROWN WITH AND WITHOUT BORON EXPRESSED AS PERCENTAGES OF TOTAL DRY MATTER PER LEAVES AND STEMS, RESPECTIVELY

	Leaves		Stems	
Amount of boron added to the nutrient solution (p. p. m.)	0.00	0.55	0.00	0.55
Starch	12.03	8.41	5.42	1.45
Reducing sugars (hexoses)	8.18	3.83	5.32	8.70
Sucrose	3.31	1.34	3.13	2.89
Total sugars	11.50	5.16	8.45	11.59

The rôle boron plays in plant growth is still an unsettled question. One thing, however, stands out in all these experiments; the growing points and other meristematic tissue seem to be greatly affected by a deficiency of boron. Another striking symptom is the breaking down of the conducting system. Both microscopic examination and chemical analyses point strongly to this conclusion. In the tomato plant it was found that starch and total sugars were more abundant in the leaves and stems of boron-deficient plants than in the corresponding tissues of normal plants. The plants were apparently able to manufacture starch and sugars, but because of broken down or undeveloped conducting systems these products remained in the leaves and stems. Analyses of tomato leaves and stems are given in Table I.

Abnormal tillering as well as the withering of the growing points were observed by Sommer[14] in her work with corn. The peculiar growth forms

[17] J. E. McMurtrey, Jr., "Symptoms of Boron Deficiency on the Tobacco Plant." Thesis submitted in partial fulfilment of the requirement for the M.S. degree, University of Maryland, 1928.

of the tomato (see Figure 4) are no doubt related in some way to the death of the terminal shoot. In fact the phenomenon appears similar to what plant physiologists call apical dominance. In many plants the growing terminal shoot suppresses the growth of lateral buds and branches. When the terminal shoot or bud is removed other buds begin their development. Thus the death of the terminal shoot acts on the plant in a manner similar to that which often occurs in pruning. The buds below this terminal shoot begin to grow as if they were no longer held in restraint. The peculiar growth of the plant shown in Figure 4 is a secondary rather than a primary effect of boron deficiency.

FIGURE 4.—Peculiar growth formations of a tomato plant grown in a boron-deficient nutrient solution.

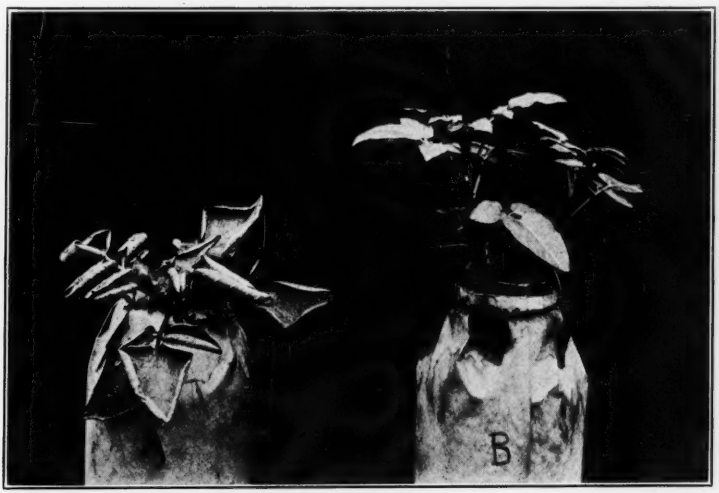

FIGURE 5.—Potato seedlings grown in nutrient solutions; *A*, boron-deficient, *B*, similar solution, but containing 0.5 p. p. m. boron.

Another interesting growth effect occurs in potato plants grown in boron-deficient solutions. The leaves become thick and rolled in a manner characteristic of potato leaf-roll disease. Starch was found in abundance in these leaves as is also the case in leaf-roll where phloem necrosis occurs. Figure 5 shows the diseased appearance of one of the boron-deficient potato plants (left) together with a normal plant (right). A better view of the diseased plant is shown in Figure 6.

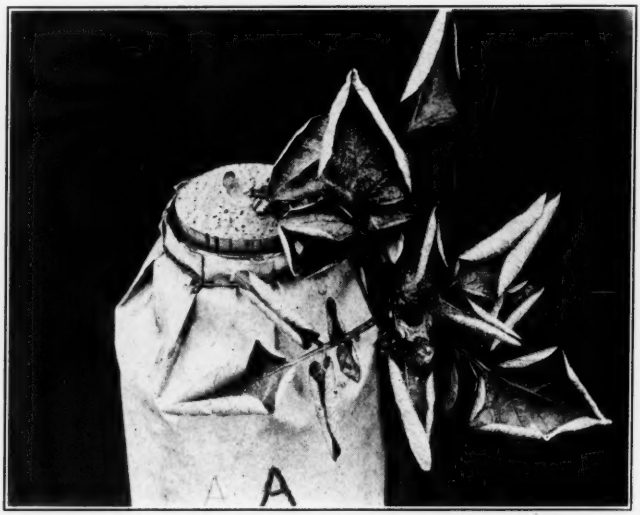

FIGURE 6.—Potato plant grown in a boron-deficient solution showing marked symptoms of leaf roll.

All these abnormal symptoms may be corrected by adding as small an amount of boron as 0.5 p. p. m. to the nutrient solution. Care should be taken not to add too much boron since a concentration of only 5 p. p. m. is extremely toxic. It is fortunate that plants grown under natural conditions normally obtain enough boron from the soil. Although the amount of boron used by plants is exceedingly small it now appears necessary to include this element among those essential for plant growth.

Micro-Photographs Aid Japanese Silk Spinners. The immense increase in the artificial silk trade has led to the use of many new methods in the process of manufacture. Two Japanese workers, Y. Kami and S. Nakashima, have introduced the use of micro-photographs for observing the minute structure of the filament in artificial silk. In this way they can quickly discover whether alterations in the conditions of spinning have any effect on the texture of the material.—*Science Service*

AN OUTLINE OF PANDEMIC CHEMISTRY*

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One of the significant developments of the last few years in higher education has come from the demand for cultural or orientation courses in the sciences. Upon no science has this demand been made more insistently than chemistry. Freshman chemistry courses have always been taught with the purpose of fitting the student for advanced work in the subject, although it has been known that only a small proportion take more than one year. A recent survey[1] of general chemistry at ten leading colleges and universities has shown that less than ten per cent of the students pursue further chemical work; this percentage will be even less in the smaller colleges, but of course more in the technical schools. The question, therefore, has been raised if a course designed primarily to meet the needs of such a small proportion can be consistent with our modern democratic ideals of education.

The commanding position chemistry has assumed in the industrial world since the World War has increased the demand for cultural or pandemic chemistry. No other subject pursued by the college student can bring him into a fuller appreciation of the industrial age in which he lives. While an examination of modern textbooks of freshmen chemistry reveals a marked increase in the space devoted to the commercial applications of the science, so much emphasis is placed upon the strictly theoretical matter that the student fails to grasp the extent of the revolution chemistry has wrought in modern civilization.

A third cause leading to the development of a new type of beginning course may be found in the growing dissatisfaction with the results achieved in the present order. Education tests have shown that our efforts at drilling chemical theories and calculations into the great majority of the students have been largely in vain. The results of the Powers' Tests[2] on ten thousand high-school students from many of the larger cities in the north and east, are sufficient to make the instructor of college freshmen wonder if such an examination of his labors would make a similar showing. The privilege of judging what weight may be given to these tests devised by our colleagues in the department of education opens the one avenue of escape which the teachers of both the high-school and freshman courses in chemistry have been all too eager to follow.

Although the need for a change in the general chemistry course is widely recognized, chemical education has been slow in meeting the need. It is

* Delivered before the Divison of Chemical Education of the A. C. S. at St. Louis, April 17, 1928.

[1] W. Haynes, *Science*, **65**, 462 (1927).

[2] S. R. Powers, THIS JOURNAL, **2**, 174 (March, 1925).

not difficult to list some of the reasons. The most obvious objection raised by the teacher trained in the present system is, how can we teach the *applications* of chemistry to industry and life before the student receives the foundations of *theoretical* chemistry? That is the major difficulty and the one we have faced squarely in all our experiments in pandemic chemistry. The difficulty is not insurmountable, however; in fact is it not due more to our point of view than to any innate shortcoming? The authors of the two volumes of "Chemistry in Industry," edited by H. E. Howe, have succeeded to a remarkable degree in presenting industrial applications of chemistry to readers with little or no theoretical training in the science; while the books were written primarily for the use of high-school students in connection with the prize essay contest of the American Chemical Society, they have found wide circulation among business executives and the cultured public. Why should not their method of presentation be adaptable to classroom use? Why has it been considered sounder pedagogy to present first a mass of theoretical matter with which the student has had no previous experience and for which he can see no use after he escapes from the course? Is it not more logical to present those facts about the operation of an industry which the student readily perceives should be a part of the equipment of an educated individual in this industrial age, and from this point let his own curiosity gradually lead him into a desire to know more about the why of the processes involved? This is certainly the method by which knowledge of the theoretical principles at the foundation of many industrial processes was developed at first. The educator who follows this plan of presentation will be as surprised by the extent to which the student seeks theoretical interpretations as were the authors of "Chemistry in Industry" in the success of their experiments to interest the public.

Another factor retarding the growth of a cultural type of course may be found again in the training of the teacher. The degree of specialization demanded of graduate students in our universities does not leave time for the acquisition of the wide store of knowledge essential to the presentation of the varied material in a course in pandemic chemistry. Active interest in research in a specialized field is vital to the life of the instructor of the advanced courses, and it undoubtedly makes a keener teacher of freshman work, but the teacher of pandemic chemistry will soon discover that he has had to learn more in one session about industrial applications than he was able to pick up rather incidentally in seven or eight years of university training.

One other hindrance has been placed in the path of development of the cultural type of course by those who have never attempted to teach the subject. The criticism is made that such a course is superficial and a "snap." The standard set in any course, however, depends more upon

the ability, training, and interest of the teacher than upon the subject-matter. It is one thing to strive to make a course interesting, and it is quite another to seek to make it easy. No subject open to freshmen affords more opportunity to secure real work as the result of stimulating a compelling interest, than the opportunity which presents itself to the teacher of a cultural course in chemistry. Through frequent quizzes and written tests the instructor who means business can quickly discover if a class is letting idle interest take the place of honest effort to comprehend the material presented.

In spite of these difficulties and apparent shortcomings, many institutions have started experiments in cultural and orientation courses. In a recent issue of *Science*[1] the statement is made that the pioneer course was introduced at Marshall College two years ago, and that similar experiments are being made at Harvard, Yale, and Cornell. In carrying on correspondence very recently with the Senators of Chemical Education representing the colleges, the author has been surprised at the large number who displayed active interest in the subject. Surely progress in this new development of chemical education has been retarded by the failure to exchange experiences among those who are engaged in experiments in pandemic chemistry. It is to help correct this situation that we venture to present an outline of the course developed during the last seven sessions, including three summer schools in which the full course was given.

In 1924 Prof. Roger W. Allen divided the freshman chemistry students at Howard College into two classes. In one class were placed those students who planned to take more than one year of chemistry; in the other class those who were interested in chemistry as a cultural subject. In the former we have been able to use successfully one of the most difficult general chemistry texts; the thorough grounding these students have received in the theoretical principles has greatly lightened our load in the upper classes. In the cultural course we broke away from the traditional type of text and used the Chemical Foundation's "Chemistry in Industry" and Slosson's "Creative Chemistry." The former proved such a happy choice that when volume II appeared it was substituted for the latter. The wide recognition these two volumes have received at the hands of the general public is sufficient to recommend them as texts in a pandemic course; since they were not written however for use in the classroom, there are certain difficulties to overcome; we have found it advantageous to place in the hands of the student mimeographed material which inserts at the proper places theoretical matter, together with lecture or laboratory experiments, essential to the scientific presentation of the subject.

The forty-two chapters of the two volumes are grouped under seven headings: Textiles, Metallurgy and Corrosion, Electrochemistry, Building Materials, Fuels and Transportation, Chemistry and the Home, and

Applied Chemical Theory. This grouping permits the correlation of related industries and gives greater unity to the course. Moreover, by this arrangement those industries calling for the more elementary theoretical discussions are placed first, so that the development of the theoretical subjects may follow the order proved sound by years of teaching in what we may call the professional type of course.

The material in the two volumes of "Chemistry in Industry" is supplemented by frequent reference to *Industrial and Engineering Chemistry*, *Chemical and Metallurgical Engineering*, and THE JOURNAL OF CHEMICAL EDUCATION. The student early learns the part played by the scientific journals in the rapid advance of the industries. He also learns to distinguish between the pseudo science of the daily press and the records of real progress in the journals. The habit of consulting these professional journals will prove of inestimable value in the student's future interests in science.

Between the seven large groupings of the chapters of "Chemistry in Industry" there is introduced material on the relation of chemistry to other fields than industrial developments. The Chemical Foundation's other volumes in the Prize Essay Series supply material which may be developed at length in institutions which are not fortunate enough to be located near industrial centers; we have never found time to devote more than a week to chemical warfare or chemistry in agriculture, and not more than two weeks to the chemistry of food and nutrition. From time to time throughout the course, however, special lectures are given on chemistry's relation to the other sciences: the contributions of chemistry to medicine form a romance that cannot be surpassed; a discussion of how the astronomer determines the chemical composition of the stars will lead naturally to such interesting problems as how he determines their size and speed, and the distances between heavenly bodies; the geologist finds radioactivity and the composition of the earth's crust significant factors in his efforts to determine the age of the earth; the physicist and the chemist work in such close harmony that the division in many fields is purely arbitrary.

The laboratory work of pandemic chemistry presents the most serious problems of the course. To follow any laboratory manual on the market would be to defeat the chief purposes of the course. After an industry is studied a visit is made, when possible, to a local plant. These inspection trips form between one-fourth and one-third of the laboratory work. In order to make the most of these trips it has been found advisable to instruct the class as to just what stages of each process will be seen; the noise and confusion in so many plants will not permit such instruction on the grounds. Plants visited in the Birmingham District include; Blast Furnace, Steel Rail, Wire and Sheet Mill, Cast Iron Pipe Company, Cotton Mill, Tannery, Portland Cement Plant, Modern Dairy, Newspaper Press, By-Product

Plant, City Water Works, Modern Bakery, Ice and Cold Storage Plant, City Health Department and Coca-Cola Plant.

Much of the laboratory time is occupied with the development of the more fundamental theories of chemistry. One of the three lecture periods a week is devoted to theoretical discussions or, if a plant is to be visited that week, instruction is given on the processes to be seen at the local unit. The laboratory period is two hours. No effort is made to prepare the student to carry on advanced work in chemistry; the experiments are selected with a view to illustrating those fundamental generalizations which will lead to a better understanding of the industrial processes. Special emphasis is placed upon the structure of matter and interpretations by means of atomic theories, for the author believes that through no other medium can a student obtain a clearer insight into the bewildering nature of chemical phenomena. The list of subjects studied in the laboratory periods include: Classification of Matter, Structure of Matter, Oxygen, Chlorine, Hydrogen, Valence, Writing Chemical Equations, Order of Activity of Metals, Periodic Table, Theory of Ionization, Some Interpretations by Means of Atomic Theories, Food and Nutrition, Manipulations, Qualitative Analysis, Advanced Laboratory Equipment (Polarimeter, Ultra-microscope, Spectroscope, Electroscope, Thermostat, Calorimeter, etc.). The presentation of these more abstruse subjects calls for unusual skill, but through close observation of the reaction of the class, the instructor can gain the student's attitude of mind, and after a little experience forestall those questions which give the most trouble. Strange as it may seem to one unfamiliar with the results obtained in a pandemic course, it is not unusual to find students in such a course who can talk more intelligently about subatomic phenomena, the periodic table, and colloidal solutions than can students considerably more advanced in the professional courses. This may be accounted for on the ground that the student in the cultural course has familiar illustrations from applied science upon which to anchor his theoretical knowledge, and also by the fact that he is given the fundamentals free from the mass of confusing detail found in the usual type of inorganic chemistry.

In conclusion we will touch upon several questions often raised by those contemplating the introduction of the cultural type of course. What if a student in pandemic chemistry becomes interested to the extent that he desires more of the science? We place him in the freshman course designed for those who prepare to follow more than one year of chemistry. Against the objection that the student thus loses a year of credit may be placed the argument that he has gained a knowledge of the relation of chemistry to civilization which, under our present system of instruction, normally would not be obtained in many years of study. Because of the broad view of the science obtained in the pandemic course, we urge, although we do not

require, all students majoring in the department to take these lectures and make the inspection trips to the local industries.

A question which should arise in the mind of every teacher of chemistry in secondary schools is, does not pandemic chemistry more properly belong to our field than to the college? Prof. Walter M. Jackson[3] has gone far toward answering that question in the affirmative. The problem of granting college entrance credit for such a course, however, will likely delay for some years the wide adoption of this change.[4] In the colleges we can at least gain elective credit for the course when students transfer to institutions which hesitate to let the cultural course take the place of their required science course. It is the firm belief of the author that all these difficulties will be removed as educators have the opportunity to observe the results obtained in this new development of chemical education.

Finally, we will call attention to three points of view on the question, often raised, of the purpose of pandemic chemistry. The chief purpose of the course is to give the student a keener appreciation of the creative age in which he lives. As already stated, no other subject can serve better this fundamental ideal of education. The whole course of instruction centers around the problem of how chemistry, often working through the other sciences, has re-created our civilization. To be ignorant of these contributions is to fail to comprehend those forces which mark our age as distinct from every preceding one.

Closely associated with this purpose is the desire to teach the student the scientific attitude of mind through the consideration of such questions as: How has this remarkable scientific progress been made? Under what conditions were the great discoveries made? What part have "lucky accidents" played? How is a discovery developed from a laboratory curiosity to a factor of profound economic moment? What attributes of mind stamp the man of scientific achievements? Consideration of these and similar problems gives the student a clearer insight into the mental life of those directing the progress of this creative age. The use of advanced laboratory apparatus to demonstrate many of the classical experiments will serve well in the accomplishment of this purpose.

The third purpose follows from the first two and, from the professional point of view, it may be considered a selfish one: it is to promote the cause of chemistry by enlisting the interest of the public in the problems of chemistry. It is a truism that in the final analysis the public pays the bills for scientific research. Only recently, however, have the sciences courted public favor. At the Nashville meeting of the American Associa-

[3] W. M. Jackson, THIS JOURNAL, **4**, 58 (January, 1927).

[4] In the discussion of this paper at St. Louis, Dr. W. D. Bancroft made the point that it should be one of the functions of the Division of Chemical Education to promote the granting of proper credit for pandemic chemistry.

tion for the Advancement of Science Dr. Ashley, speaking before the Section of Geology, stated,[5] "So today when we are faced with the most stupendous problems facing any science, we are handicapped by lack of funds and lack of interest..... The very foundations of the deep are being stirred; but the world at large knows little of it, would not understand if told, and so has little interest and is not inclined to be sympathetic to our call for help."

Chemistry has fared better at the hands of the public because we have succeeded in some measure in arousing the masses to an appreciation of the rôle the science plays in the every-day affairs of life. Upon the teachers of chemistry, more than upon any other group, rests the responsibility of keeping the public enlightened on the service of our science to humanity; as the theoretical and technical phases of the subject grow more difficult, the task of translating the results becomes increasingly difficult, and the more the demand for teachers trained in the methods of instruction called for in the cultural type of course.

For those scientists who are not in sympathy with these efforts to interpret their findings, we offer this concluding thought, also from Dr. Ashley:[5] ".... recognizing that the average scientist is not qualified by temperament or otherwise, as will be testified by any lawyer or judge, to make a simple, appealing presentation of scientific facts, let us honor rather than discourage the man, whether scientist or not, who can and will put our findings in popular form."

[5] G. H. Ashley, *Science*, **67**, 21 (January 13, 1928).

LABORATORY WORK FOR A COURSE IN PANDEMIC CHEMISTRY*

JOHN R. SAMPEY, HOWARD COLLEGE, BIRMINGHAM, ALABAMA

The laboratory work of pandemic chemistry presents the most difficult problems of this new development of chemical education. In no place is the difference more marked between the professional and the cultural types of courses. In the cultural course we are not called upon to figure out experiments to make more intelligible the scores of theories usually presented in an elementary course; neither do we have to make the student study the preparations and properties of countless unfamiliar compounds, or to learn manipulations and technic for which he will have no future use. Instead, the whole course of laboratory instruction centers around the problem of how chemistry, often working through the other sciences, has re-created our civilization; closely associated with this purpose of giving

* This paper was read before the Institute of Chemistry, Evanston, Ill., August 3, 1928.

the student a keener appreciation of the creative age in which he lives is the desire to teach the student the scientific attitude of mind in order that he may gain a clearer insight into the mental life of those directing the progress of his age.

In a previous communication[1] it has been pointed out that one of the principal features of the laboratory instruction in the course which has been developed at Howard College is found in inspection trips to a number of the industries studied. These inspection trips form between one-fourth and one-third of the laboratory work.

The weeks in which no inspection trips are made, one of the three lecture periods and the laboratory period of two hours are devoted to those fundamental theories and generalizations which will lead to a better understanding of the applications studied. Special emphasis is placed upon the structure of matter and interpretations by means of atomic theories; no other subject can be more attractively presented or may be used to give a deeper insight into the bewildering nature of chemical phenomena.

Valence and the writing of formulas and simple equations are subjects which call for such technical treatment that at one time we tried to leave them out of the list of theoretical subjects. We soon discovered, however, that without a knowledge of these the students made little progress in grasping many fundamental conceptions. The presentation of these difficult subjects calls for the greatest amount of imagination and patience, as every teacher of first-year chemistry knows. W. A. Noyes' experiment with sodium, magnesium, and aluminum has proved of great assistance in explaining valence.

The electromotive series and the periodic table are two generalizations of such far-reaching importance and they afford so many opportunities for interesting studies in similarities and contrasts in the properties of the elements that they are treated as fully as in the professional course.

The theory of ionization is the fifth and last theoretical topic treated at length. Instead of listing the postulates first, we present about fifteen experiments and then let the students draw up their own statements of the theory.

Much of the laboratory time is consumed in lecture demonstrations. We have found in the teaching of both the applications and the theory that lecture demonstrations are often as effective as individually performed experiments. H. N. Holmes' manual will furnish many striking experiments on the preparation and properties of colloids. Flotation and refrigeration are two other subjects which offer unusual opportunities for demonstrations. The destructive distillation of coal and wood may be illustrated so as to permit separation and identification of several of the well-known by-products. Finally, through lecture demonstrations, the student may see in

[1] See the preceding article.

operation many of the pieces of apparatus which have made possible more rapid advance in the science; this feature of the laboratory work will be discussed at greater length presently.

Instead of having the students determine the properties of the strange substances encountered in the professional course we examine many of the familiar products whose manufacture is studied in the lecture material. More than half a dozen of the standard tests are made on oils and fats; these include the determination of the flash-point, viscosity, surface tension, specific gravity, saponification number, and iodine number. A few typical dyes are prepared and the different methods of dyeing are illustrated. Perfumes, soaps, glass, fabrics, and building materials are some of the other products of manufacture studied. About three weeks are given to the examination of the classes of foods and the processes of digestion; the practical tests, as found in a laboratory manual for nurses, are followed rather than experiments to determine the chemical nature of the foods. The experiments on the common gases (oxygen, hydrogen, and chlorine) follow closely those of the usual laboratory manual. We also follow the custom of giving about six weeks to elementary qualitative analysis; not with any idea, however, of drilling the student in those terrifying theories of solutions dealing with the application of the mass law and the solubility product principle, but because an introduction to systematic analysis gives him a new appreciation of the scientific method.

While we make no effort to teach the students manipulations and technic for which they will have no future use, we do not hesitate to introduce them, chiefly through lecture demonstrations, to some of the pieces of apparatus which have contributed to the foundations of chemistry. The analytical balance, the ultra-microscope, the calorimeter, the thermostat, the polarimeter, the cathode-ray tube, the x-ray tube, the electroscope, the Wilson fog-track apparatus, and the spectroscope are usually demonstrated only when the student has received sufficient training to comprehend each instrument thoroughly; this is essential to the intelligent operation of the apparatus, but why should not the student who is to receive only one year's instruction be given an opportunity to learn more intimately how science gains its knowledge? To the objection that such a study is superficial, we call attention to the fact that daily we operate telephones, radios, automobiles, and many other inventions, of the mechanism of whose functioning we have little knowledge; in our age of specialization we often have to content ourselves with such superficial understanding, but fortunately we do not have to possess the knowledge of an expert to enjoy an appreciation of these separate discoveries. It is to give the student an opportunity to obtain a keener insight into the scientific method that we let him see in operation these intricate pieces of apparatus; by means of questions asked by the instructor and the class during the demonstrations

it is possible to gage to what extent the students are obtaining the desired information. This feature of the course is so novel that we shall outline briefly the high points we present under each of these pieces of advanced equipment; from this fuller treatment, however, the conclusion should not be drawn that we emphasize this part of the course more than the others.

The analytical balance is early presented. It calls for a discussion of the different systems of weights and units of measure. Then follows a historical discussion of how the balance was the one instrument which placed chemistry upon a firm scientific basis. We trace the early attempts at the determination of atomic weights, and then present some of the more recent refinements in this field. We conclude with demonstrations of the degree of accuracy possible with a good balance.

The Tyndall effect, as noticeable in a darkened room, forms the point of approach to the principle of the ultra-microscope. The relative magnifying powers of the microscope and ultra-microscope are next given; this leads to the discovery of the Brownian movement and the size of molecules. The Brownian movement may be demonstrated with the aid of the instrument from the Central Scientific Company for the detection of smoke particles. The student also is given the chance to view a colloidal solution under the ultra-microscope. We conclude with a treatment of the service of the ultra-microscope in the fields of pure and applied colloidal chemistry.

The importance of thermochemistry receives recognition in the demonstrations of the calorimeter and the thermostat. The study of the heat liberated and absorbed by chemical reactions has led to a much clearer understanding of the energy relations of chemical phenomena. The simple immersion calorimeter has played a leading rôle in the accumulation of the essential data of thermochemistry. The operation of the Emerson bomb calorimeter is described. A demonstration of the Junkers calorimeter is also given. We conclude the discussion on calorimeters with a number of commercial applications.

In the demonstration of the thermostat we show the need for an accurate control of temperature. Next we consider such relevant features of the apparatus as: the well-insulated bath, stirrer, heating coils, sensitive thermometer and the automatic regulator for controlling the temperature; the operation of the Beckmann thermometer and the automatic regulator are explained in detail.

We begin the demonstration of the polarimeter with an elementary discussion of the nature of light and of how Nicol prisms cause light to vibrate in a single plane. Vallery-Radot has disclosed how interestingly the story of optical isomerism may be told. The experiments include the effect of a change in the concentration of the solution of cane sugar, and the inversion of cane sugar with hydrochloric acid. As an example of a

recent discovery with the polarimeter, we mention Fred Allison's research into the mysterious effects of x-rays upon the rotation of polarized light.

The last five pieces of apparatus listed are selected with a view of giving more definite ideas on how science has discovered a new world of subatomic phenomena. While many of these instruments are handled more often by the physicist than the chemist, they have made such fundamental contributions to chemistry that these may well be stressed to students studying the subject from the cultural side.

The cathode-ray tube is first demonstrated. After a brief exposition of the speculations of Kanada, Aristotle, Democritus, and other philosophers, we explain how Sir William Crookes cathode-ray tube brought the first step in the solution of modern science of the age-old question of the continuity or discontinuity of matter. Through the operation of the Crookes tube the student is able to detect some of the properties of a stream of cathode rays, which later are identified as electrons, the smallest building blocks of the atom.

The next advance is shown with Röntgen's work on the mysterious rays given off by the Crookes tube, to which Röntgen gave the name x-rays. In the hands of W. H. and W. L. Bragg and the young physicist, Moseley, these x-rays disclosed many secrets of molecular and atomic structure. In the demonstration of the x-ray tube these applications to theoretical problems are stressed, for during the lecture periods we have many occasions to refer to x-rays in the fields of medicine and industry. Special mention is made of the far-reaching significance of Muller's recent experiments on the mutations produced in *Drosophila melanogaster* by x-rays.

The demonstration of the discharge of an electroscope by a radioactive substance serves to open the discussion of Becquerel's "lucky accident" and the subsequent work of M. and Mme. Curie on radium. Recently the Central Scientific Company has placed on the market a fog-track apparatus which makes it possible for the student to actually witness radioactive disintegration. Interesting discussions can be given upon the principle of the C. T. R. Wilson fog-track method and on a number of revelations of atomic structure made possible through radioactivity.

The spectroscope completes the list of advanced equipment. Before we explain the usefulness of the instrument in unraveling the story of atomic structure, we demonstrate how it is possible to identify different elements through the examination of their flame spectra; the student readily perceives the application to analytical chemistry. The broader service of the spectroscope may be explained in the astronomer's determinations of both the composition and speed of the stars. We then explain in an elementary fashion how Niels Bohr developed his theory of atomic structure to explain spectroscopic data. To complete the picture of atomic structure we give a brief explanation of the Lewis atom, and then recall to the stu-

dent's mind how many of the relationships of those fundamental generalizations, the periodic table and the electromotive series, may be interpreted by each of these models of the atom.

In this discussion of the fundamental theories treated in the laboratory work it may appear that we have strayed away from pandemic chemistry. What we have done is to present more fully than is usually done in the professional course a few of the most important theories. You perceive that we have omitted many of the theoretical topics essential to the understanding of the technicalities of this science; we have tried to concentrate the student's attention upon only those subjects which have led to the most fundamental advances in theoretical and applied chemistry. When we succeed in arousing the same interest in these important problems of theoretical chemistry considered in the laboratory part of the course that the student has naturally in the triumphs of applied science studied in the lecture material, then we shall have progressed far toward the goal of pandemic chemistry.

Gas "Dope" No Good, Chemists Declare. Secret "dope" sold to private owners for addition to motor gasoline is at least a delusion and possibly a snare. Investigations described at the recent Institute of Chemistry of the American Chemical Society show that chemicals of real potency in the betterment of automobile fuel are already well known and are now marketed by responsible manufacturers. There is no secrecy in their scientific formulas. The search for anti-knock material has been highly scientific and exhaustive. It is probable that no ordinary person outside the great research laboratories has any chance at all of producing something of value to drop by the teaspoonful into a tank of "gas."

Among the chemicals recently sold widely without basis of merit are nitro-benzene and ortho-nitro-toluene, fixed up in perfumed and colored mixtures. These coal-tar products do nothing of significance to the gasoline and may be regarded as frauds.

More deceptive is the widely known use of mothballs. These may be used either as such, or may be purchased at times in a crushed form under some non-descriptive trade-mark. Experiments carried out by the Bureau of Mines have revealed that mothballs, known to chemists as naphthalene, have practically no effect, good or bad, on the power qualities of gasoline. The substance does, however, increase the viscosity of the fuel so that the spray of the material in the motor carburetor is cut down in volume. Particularly in the Model T Ford it is well known that most owners waste a large part of their fuel by feeding too rich a mixture to the carburetor. Naturally, the addition of naphthalene cuts down the supply and actually gives more miles per gallon. One could have gotten the same result without expense merely by turning down the needle-valve. With the up-to-date high efficiency carburetors, however, the naphthalene is worthless.

It is considered possible here that some anti-knock substance of lower activity than that of the present ethyl fluid may be developed and used in larger proportion because of possible cheapness. Such a preparation may be a compound of some cheaper metal than the lead now used. But there will be no mystery about its identity when it comes.
—*Science Service*

OPTICAL EXPERIMENTS WITH ELECTRONS. PART II

L. H. GERMER, BELL TELEPHONE LABORATORIES, NEW YORK CITY

The Refraction of Electron Waves

We shall now return to a further consideration of the regularly reflected beams. Knowing that electrons have a wave-length equal to h/mv, we can plot the curve showing the intensity maxima of the regularly reflected electron beam against wave-length instead of against the square root of the voltage which was used before. Figure 10 shows a replot of Figure 2 after replacing voltage by the equivalent wave-length.

The coördinates of the curve on the right of Figure 10 are intensity of the regularly reflected beam and reciprocal of wave-length. On this plot selective reflection of x-rays would occur at equally spaced intervals. (See Figure 3.) The actual wave-lengths at which these x-ray reflections would occur are indicated by the positions of the vertical arrows. The numbers attached to these arrows are the orders of the various "Bragg reflections." (The surface of the crystal is the same crystallographic plane used in the diffraction experiment, shown in the center of Figure 4. For this surface $d = 2.03$ A.)

All the maxima of the electron reflection curve fall to the left of the positions of what appear to be the corresponding x-ray reflections. The displacement decreases toward the higher orders. Now this is the behavior to be expected if the nickel crystal had an index of refraction for electron waves which is different from unity. We may think of the vertical arrows in Figure 10 as indicating the positions at which the maxima of the electron reflection curve would occur if the refractive index were unity, and we can use the displacement of each observed maximum from the position of its corresponding arrow to calculate a value of the refractive index.

In this way from the data of Figure 10 we obtain six different values of refractive index, corresponding respectively to six different electron wave-lengths. In Figure 11 these six values of refractive index are plotted against the reciprocal of wave-length. This is a dispersion curve of our nickel crystal for electron waves. It is of course only tentative, as there are not enough points to establish the curve very accurately and, furthermore, it is only a conjecture that the displacements of Figure 10 arise because of a refractive index different from unity.

When data are taken at an angle of incidence other than 10° a curve showing selectivity of the reflection is obtained which is somewhat similar to the right-hand curve of Figure 10. Data are then available for calculating additional values of refractive index, and Figure 12 shows the dispersion curve with the addition of points obtained at angles of incidence other than 10°. By taking data at angles of incidence which are close

together the density of experimental points along this dispersion curve can be made as great as we like.

When all of the data of Figure 12 are carefully considered, they indicate

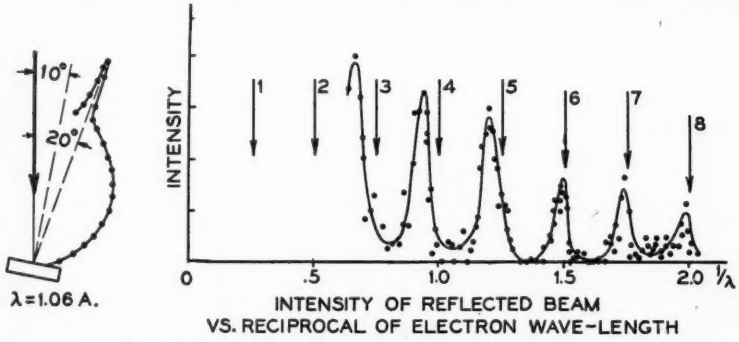


FIGURE 10.—The selectivity of electron reflection—a replot of Figure 2 using wave-lengths instead of equivalent voltages.

strongly that the departures of the intensity maxima of the electron beams from those of the x-ray beams are properly accounted for by assuming a

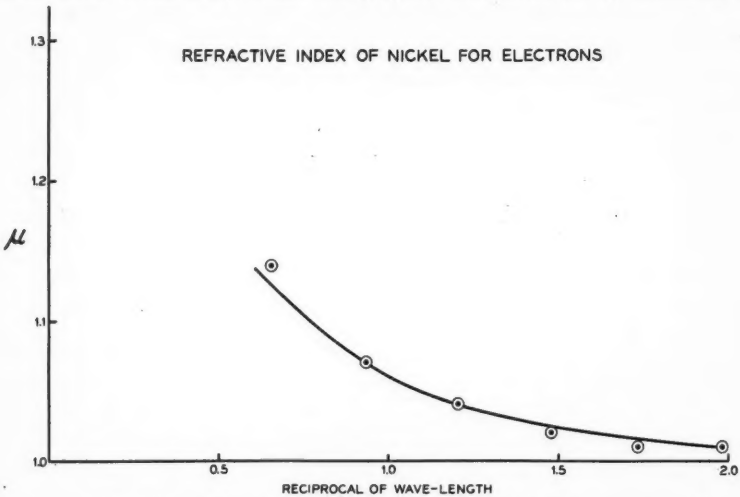


FIGURE 11.—Tentative dispersion curve of the nickel crystal for electron waves (from data taken at 10° incidence).

refractive index giving a dispersion curve of this form. This assumption adequately accounts for the facts, and it seems that no other assumption will account for the facts unless it gives essentially the same law for the

departures of the electron beam positions from the x-ray beam positions. Furthermore, this dispersion curve does adequately account for the dis-

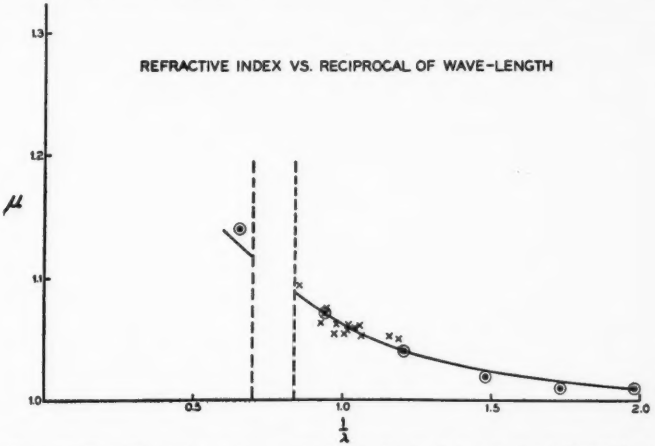


FIGURE 12.—Dispersion curve. Circles indicate data obtained at 10° incidence, and crosses data obtained at angles of incidence other than 10°.

placement of the assemblage of electron diffraction beams, which was considered previously,[1] from the corresponding assemblage of x-ray diffraction beams.

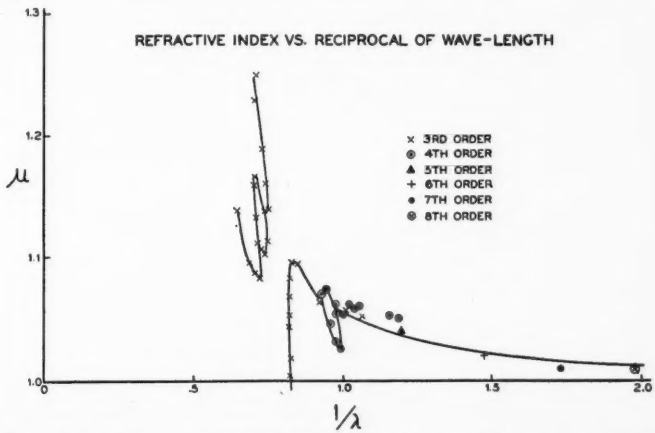


FIGURE 13.—Complete dispersion curve of the nickel crystal for electron waves.

In plotting Figure 12 a number of experimental points were purposely omitted in order not to distract attention from the general course of the

[1] THIS JOURNAL, **5**, 1041–55 (Sept., 1928).

curve. These missing points are added in Figure 13. At present we are entirely ignorant of the meaning of the surprising loops in this dispersion curve. In our present state of ignorance the break in the continuity of the curve near the wave-length 1.3 A. is certainly suggestive of the optical phenomenon of anomalous dispersion, and these loops are suggestive of double refraction.

. . . . .

I want to return now to the diffraction experiment in which the nickel crystal was bombarded normally by electrons. Now that we know what the refractive index of nickel is for electrons of different wave-lengths, we understand why the assemblage of the electron diffraction beams arising from the crystal was very similar to the theoretical assemblage of x-ray diffraction beams, and why the electron beams were all displaced from the positions of the corresponding x-ray beams. The dispersion curve accounts quantitatively very nicely for these displacements. We are now able to assign Miller indices to each of the electron beams just as Miller indices are assigned to each Laue x-ray diffraction beam arising from a crystal. I shall show some of these electron beams merely as exhibits.

Figure 14 shows again the 54-volt diffraction beam. We know now that this is really a (331) reflection according to x-ray terminology. Because the refractive index happens to be 1.13 instead of unity, as it is approximately for x-rays, this reflection occurs at 50° for a wave-length of 1.67 A. instead of at 44° for a wave-length of 1.49 A., which are the conditions for the occurrence of a (331) reflection of x-rays.

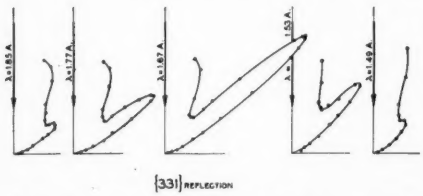


FIGURE 14.—A replot of Figure 7, designating this electron diffraction beam by its Miller indices according to the conventional x-ray nomenclature.

The curves either side of the center in Figure 14 give an idea of how selective is the occurrence of this diffraction beam. The disappearance of the diffraction beam as the wave-length is changed from the critical value of 1.67 A. is nothing like so sudden as the disappearance of an x-ray diffraction beam under similar conditions. This must be attributed to the fact that the penetration of electron waves into the metal is very much less than the penetration of x-rays of the same wave-length. In fact we have used the intensities of the beams shown here to calculate the exponential extinction factor of the metal for electrons having a wave-length of 1.67 A. This is a fairly simple calculation in resolving power. It comes out that, of the electrons of this wave-length incident upon a (111) layer of nickel atoms, about 60% go through the layer without accident.

Figure 15 shows the occurrence of this same diffraction beam in the second order. The wave-length is 0.778 A. at which the refractive index is about 1.04, so that in the second order this beam occurs very close to 44° which would be the angle of occurrence if the index were unity. According to x-ray nomenclature this is a (662) reflection.

Figure 16 shows again the 65-volt beam which is now properly designated as a (422) reflection. Figure 17 shows this beam in the second order—an (844) reflection.

Figure 18 shows a (551) reflection. The curves of this figure show the selectivity of this beam. All of the diffraction beams show a selectivity of this nature. These curves are similar to the curves of Figure 14, and they are typical of the behavior of all the beams (except one, a (442) reflection shown in Figure 21).

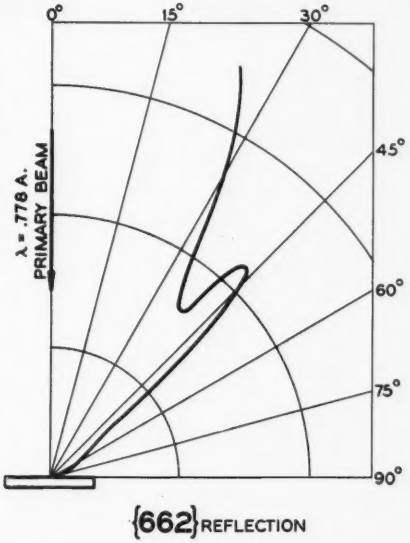


FIGURE 15.—The second order of the electron diffraction beam shown in Figure 14.

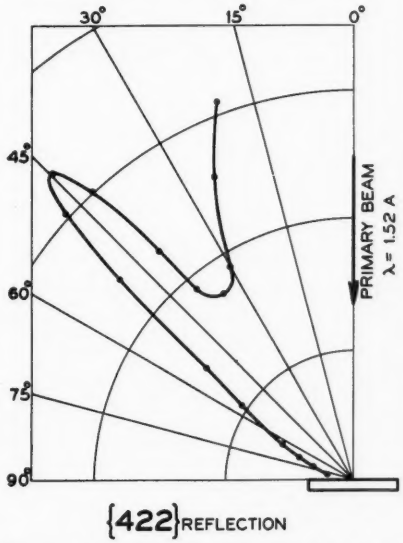


FIGURE 16.—A replot of Figure 8 with the beam classified in the conventional manners.

Figure 19 shows a (622) reflection. This is another second order beam. The first order of this beam is of unusual interest and I shall postpone showing it until a little later (Figure 27). Figure 20 is a (533) reflection.

Figure 21 shows development curves of a (442) reflection. This beam is unusual in that it occurs at a wave-length of 1.19 A., which is close to the critical region of the dispersion curve.

The center of this critical region is at about 1.3 A., and the curves of this figure show diffraction at wave-lengths within the critical region. The diffraction beam is extremely weak at 1.29 A., and much weaker than we would expect at 1.26 A. This (442) reflection is the only diffraction beam which shows any departure from the gradual approach to a maximum intensity as we come to the right wave-length for the beam. On the short wave-length side—at the right of Figure 21—the gradual weakening of the beam is quite normal. Curves showing this have been omitted. Tentatively we attribute the weak beam found at 1.29 A. to diffraction from only the top layer of atoms of the crystal.

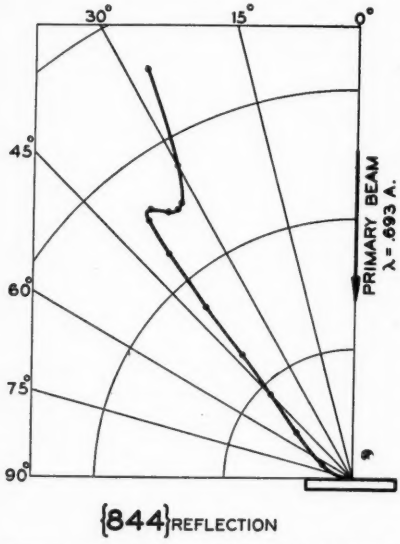


FIGURE 17.—The second order of the diffraction beam shown in Figure 16.

Figure 22 shows the last of these exhibition curves of various electron diffraction beams. It represents a (773) reflection.

. . . . . .

It is likely to occur to any one that we could have used the departure of the assemblage of electron beams from the theoretical assemblage of x-ray beams to calculate for each electron beam the refractive index, and thus

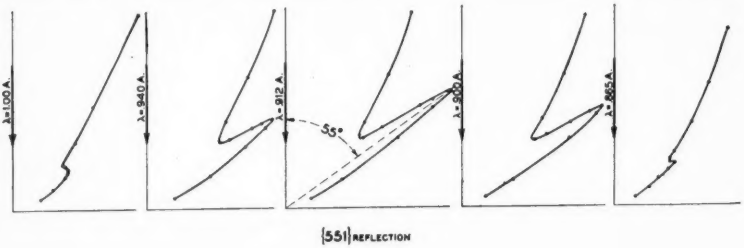


FIGURE 18

establish the general course of the dispersion curve without recourse to the reflection experiment. Because of the limited number of diffraction beams we could not, of course, hope to discover the elaborate flourishes of this curve. The attempt to establish even the general trend of the dispersion

curve from the diffraction data was not successful for three different reasons. In the first place the diffraction apparatus was not so accurately built as the reflection apparatus and the positions of electron beams could not be determined with quite the necessary accuracy. All of the diffraction beams which have been shown are quite broad in angle, which was almost entirely due to the poor resolving power inherent in the geometry of the apparatus. In the second place, in the diffraction apparatus a beam of course changed its position with changing potential. It was thus more difficult to determine accurately the voltage at which a beam came to its maximum development than was this determination in the reflection apparatus. In the third place, there are some irregularities in the diffraction pattern which were very confusing before the dispersion curve was established.

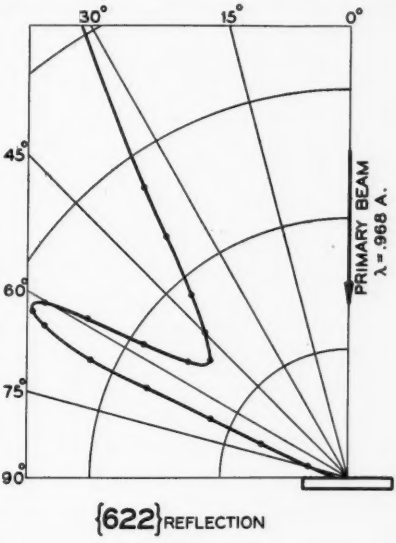


FIGURE 19

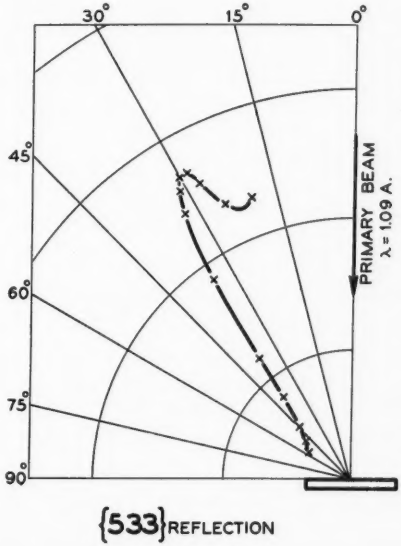


FIGURE 20

When index of refraction is calculated for each electron beam from the displacement which the beam shows from the position corresponding to unit index we get values which are shown plotted in Figure 23. The solid curve in this figure is the dispersion curve previously determined. The points indicated by crossed circles are obtained from the diffraction beams for which the data are

known to be most reliable. The departures of these points from the solid curve are not larger than can be attributed to experimental errors. (For example, the considerable departure of the point on the extreme left

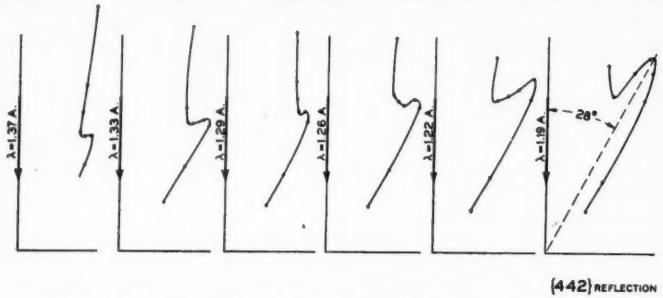


FIGURE 21.—The development of a (442) reflection, showing diffraction within the region of anomalous dispersion.

corresponds to an error of about 5 volts in determining the potential at which this beam reaches its maximum development.)

Application of Electron Waves to the Study of Crystal Structure

I want to turn now to considerations of a different and perhaps a less important nature. It will be remembered that the discovery of x-ray diffraction led immediately to important information of two quite different kinds. In the first place the wave nature of x-rays was established, and in the second place the structures of various diffracting lattices became known. We are convinced that the discovery of electron diffraction opens up a similar dual field.

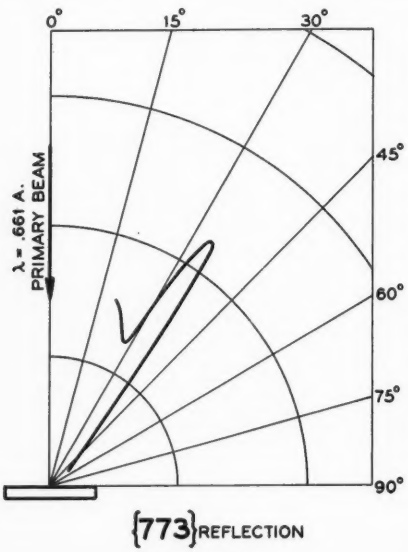


FIGURE 22

Electron waves differ from x-radiation of the same wavelength in certain important respects; they are scattered much more efficiently by the atoms of the crystal, and they are extinguished in penetrating into the crystal at a much more rapid rate. Thus the diffraction of electron waves occurs

entirely in the few top layers of atoms at the very surface of a diffracting crystal. We believe that this circumstance will prove to be of considerable importance—as it suggests that in electron diffraction we have a new means of exploring the region at and near the surface of a crystal, a region which is inaccessible to x-ray investigation. This new tool, which may well be called "electron diffraction analysis," may be expected to yield results concerning surfaces quite similar to the results which x-ray diffraction analysis yields concerning volumes. A considerable amount of information regarding the surface of our nickel crystal has been literally forced

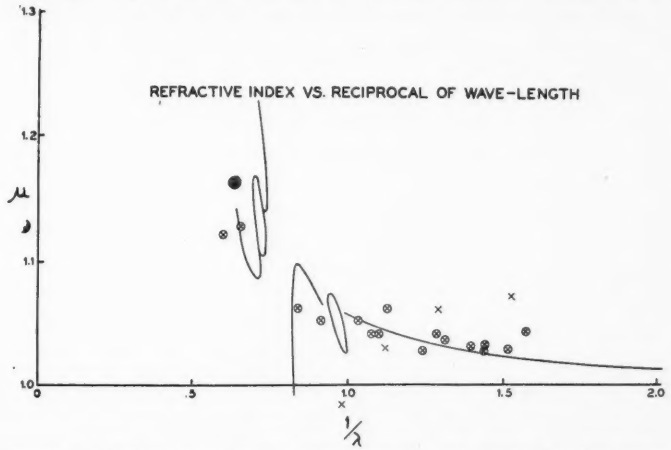


FIGURE 23.—Refractive indices calculated from the data of the diffraction beams.

upon us, and there seems reason for believing that we have now at hand a tool of really tremendous power for studying the micro-structure of surfaces.

The first information which we obtained concerning the surface of our nickel crystal had to do with the amount of gas which settled upon the crystal in vacuum. In the diffraction apparatus, in which the primary electron beam struck the crystal normally, we were able to heat the crystal by electron bombardment thus cleaning its surface. From the diffraction patterns observed we were able to tell when the surface was really clean—clean to the very last layer of gas atoms.

In the third section of this paper was described the occurrence of non-selective diffraction beams which proceeded from the surface near to grazing emergence as if the surface were a plane diffraction grating. These beams were present for a time after the surface had been cleaned by heating. After such a cleaning they were initially strong, but as time went on they gradually weakened and finally disappeared. The absence of selectivity

in these beams is evidence that they arose from a single layer of atoms. This weakening and final disappearance, after the surface had been cleaned, clearly means that the surface layer of atoms on the crystal was changing. Almost certainly gas atoms were settling upon the surface, and the presence of these beams grazing the surface means that the surface was clean—that there were absolutely no gas atoms on the surface.

In Figure 24 is shown the appearance of these non-selective grazing beams in the *C*-azimuth of the crystal. The curves of this figure are plots of the intensity of scattering as a function of wave-length at different angles of emergence. As the grating space in this azimuth is 1.24 A. we expect a grazing beam to occur for a wave-length of 1.24 A. We see from this figure that a beam actually does occur at 5° from grazing ($\theta = 85°$) for a wave-length slightly less than 1.24 A., and that as we come up from the surface this beam occurs at shorter and shorter wave-lengths. The wave-length changes with angular position in the right way to satisfy the plane grating formula with a grating constant of 1.24 A. Similar beams occur in the *A*- and *B*-azimuths satisfying the grating formula with a constant of 2.15 A.

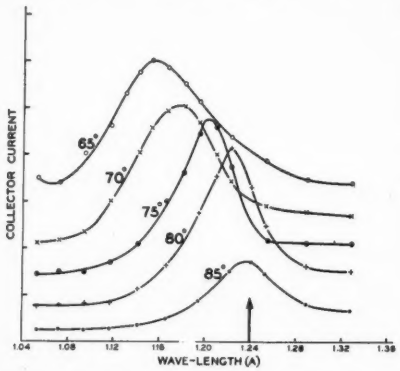


FIGURE 24.—Intensity of scattering vs. wave-length at various angles of emergence close to grazing, in the *C*-azimuth of the crystal. The beams exhibited here are found only immediately after the surface has been cleaned by heating.

The importance of the beams shown in Figure 24 lies in the fact that they are present only when the surface of the crystal is clean. Consequently, the occurrence of these beams can be used as a criterion to tell when the surface is clean, and their intensities can be used as a qualitative measure of the amount of contamination on the surface.

Within a fairly short time after the surface had been cleaned by heating, the beams shown in Figure 24 had entirely disappeared, due to the adsorption of gas upon the surface. They could then immediately be brought back to their original intensities by heating the surface to about 900°C. The fact that this mild heating was sufficient to clean the surface completely is new information of some importance in itself—of course, utterly beyond the possibility of study by the microscope or by x-rays. Evidence regarding gas on surfaces obtained by photoelectric and thermionic means does not seem to be in agreement with these findings. It seems to us that

the information obtained by means of electron diffraction is perfectly clear and unambiguous.

After cleaning the surface, by heating to 900°C., gas gradually settled back on the crystal, first destroying these "grazing beams" and then gradually weakening the selective diffraction beams themselves. In the course of time they too became quite weak, due to a thick layer of gas.

Figure 25 shows how one such beam became weakened. Curve *a* in this figure is a (331) reflection from a clean surface, which has been shown before in Figures 7 and 14. Curve *b* shows how this reflection became weakened by the adsorption of gas. The amount of gas necessary to cause the disappearance of the grazing beams, which must be at least one layer of atoms, did not much affect this beam arising from the body of the metal. Thus the amount necessary to weaken this beam greatly must have been many layers of atoms. We have found, then, that many layers of gas will be deposited upon a clean metal surface and adhere to it, even in our best available vacuum. This again is a result of some consequence which has been obtained by means of our new method of crystal analysis.

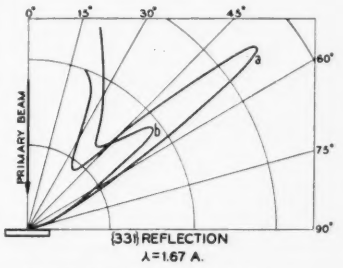


FIGURE 25.—The effect of gaseous contamination of the crystal surface upon the intensity of a (331) reflection. Curve *a* shows this reflection from a clean surface and curve *b* the reflection from a surface which has been contaminated by several layers of gas.

By far the most striking information which we have obtained regarding the gaseous contamination of our crystal surface, concerns the crystalline arrangement of the first gas molecules to deposit themselves upon this surface. Starting in with a completely clean surface the grazing beams gradually weaken, showing the deposition of gas. At an early stage of this gas deposition an entirely new class of diffraction beams makes its appearance. These new beams increase gradually in intensity, reach a maximum and then decrease, finally disappearing at about the same time as the disappearance of the "grazing beams." These new beams are plane grating beams arising from the very first layer of gas atoms on the crystal surface. One family of these beams appeared in each of the three principal azimuths of the crystal.

The appearance of these new transient beams in the *C*-azimuth is shown in Figure 26. The curves of this figure are electron scattering curves in the *C*-azimuth for a series of different electron wave-lengths, while the crystal was in the transient condition just described. On each arrow indicating the primary beam is printed the wave-length of the electrons giving rise to the curve. Below each curve is the wave-length which would

give a first order plane grating diffraction beam at the angle indicated in the figure. It is evident from a comparison of these numbers that the diffraction beams shown by these curves are really "one-half order" beams. The wave-lengths calculated from the angles of occurrence of the beams are

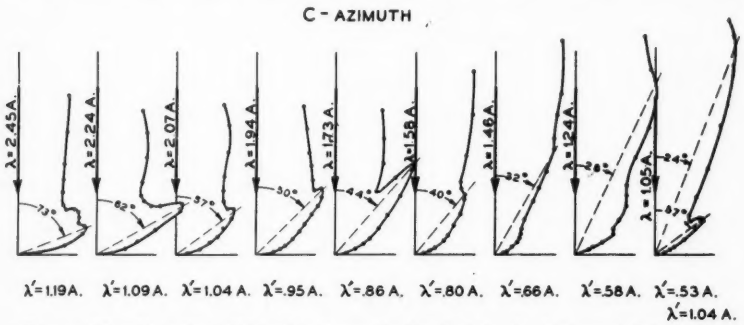


FIGURE 26.—Transient diffraction beams in the *C*-azimuth of the crystal arising from a single layer of gas atoms. Electron wave-lengths designated by λ. Wave-lengths calculated by assuming $n = 1$ in the plane grating formula $n\lambda = D \sin \theta$ designated by λ'.

consistently equal to one-half of the actual wave-lengths of the electrons giving rise to the beams. (In the curve on the extreme right there is also a first order diffraction beam.)

The obvious interpretation of the occurrence of beams of one-half order is that we have misjudged the value of the grating constant. The con-

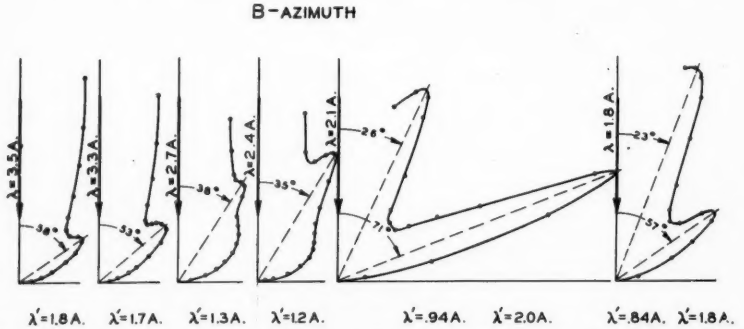


FIGURE 27.—Transient diffraction beams in the *B*-azimuth arising from a single layer of gas atoms; also a (311) reflection.

stant of the grating giving rise to these beams is evidently equal to twice the separation between rows of nickel atoms in this azimuth.

From the way in which these transient beams occur we know that they are due to diffraction from a layer of gas. From the characteristics of

the beams we have just concluded that, at least in the *C*-azimuth, the gas atoms (or molecules) constituting this layer are separated by distances twice as great as the separation of nickel atoms.

This double spacing of gas atoms is also shown in the other azimuths

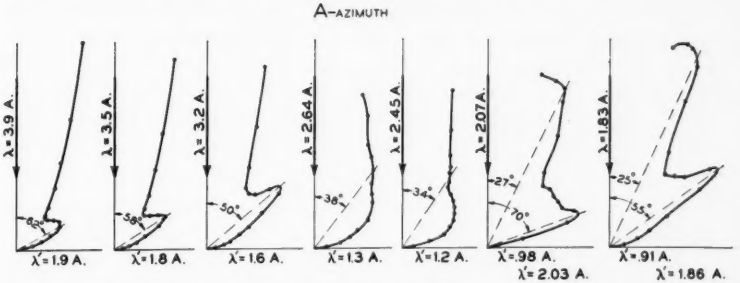


FIGURE 28.—Diffraction beams in the *A*-azimuth from a single layer of gas atoms.

of the crystal. Figure 27 shows transient diffraction beams of one-half order occurring in the *B*-azimuth. This figure is quite analogous to Figure 26. It also shows one-half order and first order beams. The tremendous first order beam shown on the curve second from the right is a (311) reflection. It is of unusual interest because it occurs so close to grazing the surface. The second order of this beam was shown in Figure 19.

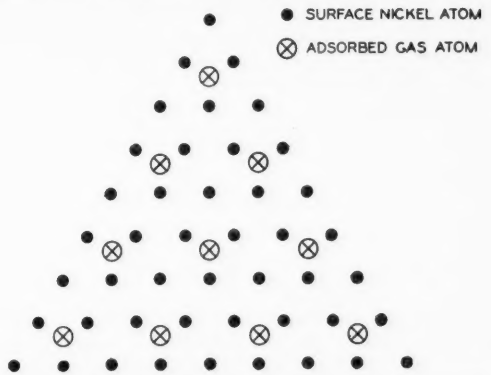


FIGURE 29.—The structure of the first layer of gas atoms to be adsorbed upon a clean (111) surface of a nickel crystal.

In Figure 28 are exhibited in the same manner the transient one-half order beams in the *A*-azimuth.

By means of this diffraction analysis we have thus deduced the fact that the first gas atoms to settle upon the clean surface of our nickel crystal

in vacuum arrange themselves in a structure similar to the structure of the top layer of nickel atoms but having a scale factor twice that of the nickel atoms. This arrangement of nickel atoms and gas atoms is shown in Figure 29.

Now looking back to Figures 26, 27 and 28 it will be noted that, on each figure, the one-half order beam shows marked change of intensity with change in position. This seems to be due to interference between the electron beams diffracted from the layer of gas atoms and from the underlying layer of nickel atoms. These intensity data have been used to calculate the separation between the gas atoms and the surface nickel atoms. This calculation yields the value 3.0 A as the distance of this separation. This is about fifty per cent greater than the separation of layers of nickel atoms (2.03 A).

It has already been stated clearly that the diffraction beams due to the adsorbed layer of gas atoms cannot be made to remain unchanged for any considerable length of time. They begin to develop some time after the surface of the metal has been cleaned, increase to a maximum, then decrease and finally disappear—clearly indicating the accumulation of a large amount of gas on the surface. The course of this development and decay can be destroyed by a mild heating of the crystal—to about 150°C. Such a heating does not alter the intensity of the grazing beams—meaning clearly that the *amount* of gas on the surface is not altered by the heating. The heating does however completely destroy the "one-half order" beams in all three azimuths. Evidently the heating does not change the rate of deposition of gas on the surface, but it does destroy the regular arrangement of the gas atoms. Apparently, we can have the gas on the surface as a two-dimensional liquid instead of a two-dimensional crystalline solid. The melting point of this two-dimensional gas crystal is found in this manner to be in the neighborhood of 150°C.

Information of the nature of that which we have obtained regarding gas on surfaces may turn out to be of very great scientific importance. The whole problem of chemical catalysis, which I think is essentially unsolved, concerns itself with what occurs on the surface of a solid body. The United States Government maintains quite a sizable laboratory, one of whose chief functions is to discover, if possible, what happens when nitrogen and hydrogen are brought together on the surface of certain oxides. We believe that this electron diffraction analysis offers the only means which has ever been suggested for a *direct* study of questions of this nature.

. . . . .

Another impending application of electron diffraction analysis is its use to study the perfection of crystal surfaces. We have some information bearing upon the condition of our crystal surface. At present it is in a

rather undigested state, but even so it may be worthwhile to indicate the facts which we have observed, and the nature of the conclusions which can be drawn from them.

Some time ago it was pointed out that the degree of selectivity of a diffraction beam can be made use of to calculate the rate of extinction of a train of electron waves in penetrating into the metal, and the result of one such calculation was given. Probably the most convenient data to use for this purpose are data on a reflection beam such as one of the peaks in Figure 10. Although the data which we have at hand permit a calculation of this kind to be carried through completely in only one case, we do know qualitatively that the penetration increases considerably as the wave-length decreases—that is, as the voltage is increased.

When the penetration is known we should be able to use the measured angular widths of reflection beams to calculate the mean size of facet on the surface of the crystal. Appreciable angular width of a reflection beam must definitely mean poor resolving power of the plane grating of atoms on the surface of the metal. This can arise because the wave-front of an electron is very restricted, or because the surface of the metal is made up of many different facets, each of which is rather small. As a matter of fact electron reflection beams from a nickel surface, which has been well etched by acid and subsequently heated only to about 900°C., are exceedingly narrow—indicating good resolution of the crystal for electron waves. This means definitely that such a surface has very large facets and, more important, that the wave-front of an electron is very great. Vigorous heating of such a crystal surface greatly increases the angular width of these reflection beams—showing that the resolving power of the crystal has been decreased. We have data at hand from which it is possible to calculate the mean size of superficial facet on our nickel surface after various heat treatments. This size is exceedingly small in general, in certain cases far less than a light wave-length.

This type of resolution calculation is more difficult than the calculation regarding penetration—and we have not yet carried it through. The qualitative results are however of some interest as this type of information regarding surfaces seems not to have been available heretofore.

The curves of Figure 30 show how very severe heating of the nickel crystal changed the resolving power of the surface. The curve on the left shows a certain Bragg reflection beam from the crystal surface while the facets were still large—before the severe heating. After heating the crystal almost to the melting point, the shape of this beam changed to that shown at the right. In the case of the beam obtained before heating the resolution is about as good as the geometry of the apparatus will allow.

We have quite independent evidence from which can be tentatively inferred this same conclusion regarding change in size of facet after heating.

The location of one of the intensity maxima of Figure 10 is determined by coherent reflections from different planes of atoms in the crystal. The positions are displaced from the positions of the x-ray maxima because the

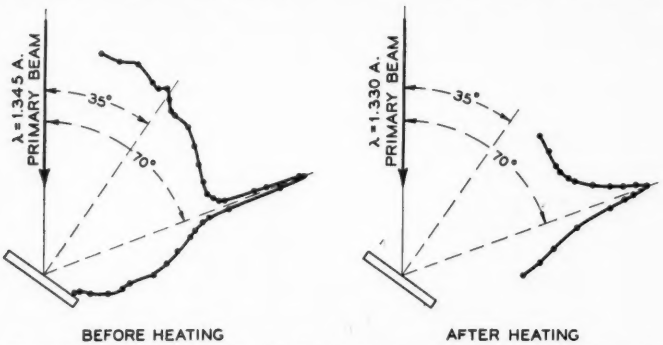


FIGURE 30.—Curves showing the effect of vigorous heating upon the inherent resolving power of the nickel crystal.

different planes are separated by material having a refractive index different from unity. If individual facets were small there would be the possibility

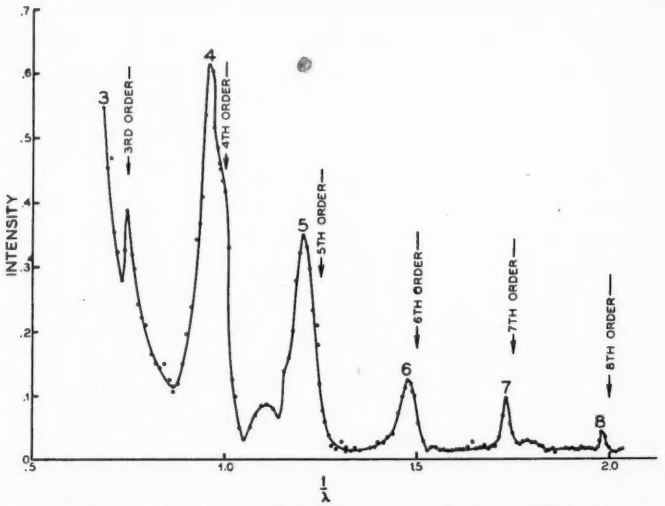


FIGURE 31.—Showing the selectivity of electron reflection at 10° incidence, after vigorous heating of the nickel crystal (cf. Figure 10).

of coherent reflections by planes of atoms on the surfaces of different facets. These planes of atoms are separated by empty space—having unit refractive index. Thus we might expect that, after severe heating, the selectivity

curve would be modified by the appearance of small intensity maxima at positions corresponding to unit refractive index.

Figure 31 shows the appearance of the 10° selectivity curve after the crystal had been heated sufficiently to cause considerable broadening of the Bragg reflection beams. In this figure the vertical arrows again indicate the positions of intensity maxima corresponding to unit refractive index. It will be noted that in the third order there is a small intensity maximum just at the position corresponding to unit index, and there is the indication of such a maximum in the fourth order.

• • • • •

In concluding this paper I want to point out that at present we have many unsolved problems. Upon the solutions of some of them we are actively engaged at present, and these need not be mentioned here. There are however at least two problems of some interest toward the solutions of which we seem to be making no immediate progress. It is fitting that mention should be made of these two problems.

In the first place there are some irregularities in the Laue diffraction pattern which have not been explained. These irregularities are confined to the *C*-azimuth and to the third order in the *A*-azimuth. They are exhibited here by the points in Figure 23 which fall widely off from the dispersion curve. We are inclined to attribute these irregularities to imperfections of the surface of the crystal, and it seems that it might be possible to learn something about these imperfections from a study of the irregularities observed.

The other unsolved problem is a rather nice problem in crystal structure. When the amount of gaseous contamination of the crystal surface is considerable, an entirely new set of diffraction beams arises which we have not been able to account for. These beams are found only when the gas on the surface amounts to many layers of atoms, sufficient, for example, to weaken the (331) reflection to the condition of curve *b* in Figure 25. Under these conditions new beams are found simultaneously in the *A*-, *B*-, and *C*-azimuths of the crystal, all at co-latitude angles of 58° for the same electron wave-length, 1.17 A. The existence of these diffraction beams seems to prove that there are some crystalline regularities in even a very heavy layer of gas atoms. What sort of regularities can give rise to a pattern of this nature we have however been unable to deduce.

Prussic Acid to Protect Cotton. Prussic acid is the most suitable agent for protecting cotton from the fungi and bacteria that prey upon it when it is stored, announced the Ministry of Agriculture at Cairo, Egypt, as a result of much research on the subject. This acid protects the cotton successfully and has no harmful effect on the spinning or other properties.—*Science Service*

A FEW SUGGESTIONS FOR TESTING IN HIGH-SCHOOL CHEMISTRY

G. ALBERT COOK, SENIOR HIGH SCHOOL, ANN ARBOR, MICHIGAN

One problem the high-school chemistry teacher faces is that of testing the pupils' memory of the properties of numerous substances. The following method has been found very successful:

Directions.—Check *all* the appropriate properties:

Cl_2	Na	N_2	HNO_3	O_2	
( )	( )	( )	( )	( )	gas at room temperature
( )	( )	( )	( )	( )	strong acid
( )	( )	( )	( )	( )	metal
( )	( )	( )	( )	( )	component of the air
( )	( )	( )	( )	( )	poisonous gas
( )	( )	( )	( )	( )	forms base after reaction with water

Method of Marking.—Each group of three parentheses counts one point; a mistake in a group takes off the whole point.

The first time the students have a question like this on a test, it should be made clear to them that they are to start with the first substance; *e. g.*, chlorine, and look at each property (in the right-hand list) in turn to see whether it applies to that substance. If it does, a check-mark should be placed in the parentheses under the substance and opposite the correct property; if not, the parentheses should be left vacant.

The purpose of marking the responses in groups of three is this: the chance of *guessing* whether or not to put a check mark in any pair of parentheses is just one-half; by the theory of probability, the chance of guessing *correctly all three* of a group would be one-eighth. It is a safe rule to have the guessing chance less than one in five, so this method is perfectly safe.

The same idea can be applied to the true-false method. I have found that in chemistry there are a great many items to test which involve only two alternatives. These can be tested by brief statements, with directions to mark *T* for true and *F* for false. These statements are placed in groups of three on the mimeographed test, and are marked that way, the whole group being counted wrong if a single statement is incorrectly designated. If the reason for this is explained to the pupils, there will be no trouble on that score. Pupils rather like the true-false method. Of course, it would not be a good plan to have very many such groups. The greater the variety of the methods of testing on a single test, the more interesting it becomes for the pupil to take.

It is probably not a good plan to use exclusively these new-type methods of testing. At the bottom of the mimeographed sheet, I have found it a good plan to have a statement like the following:

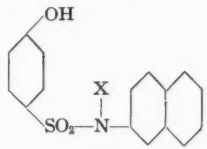
"On the extra (blank) sheet given you, first write your name, then write out:

1. The distinctions between a compound and a mixture.
2. etc."

In this way the pupils still get some writing to do, but not so much as to burden the teacher with wading through a sheaf of the old-type test "blue-books."

A CORRECTION

Through inadvertence in proof reading of the article on "Chemical Education at the University of Vienna" by John S. Reese, IV, which appeared in the September number, the structural formula for a typical dye was incorrectly printed at the top of page 1128. The correct formula is as follows:



Photographs Made of Microscopic Crystals. When we look at a photograph, or at a movie film, we are really crystal gazing, although we may not be aware of it. We do not see the crystals, because they are too small to be distinguished separately without a microscope. At the recent meeting of the Institute of Chemistry of the American Chemical Society, Dr. C. E. Kenneth Mees, of the Eastman Kodak Company, explained how the new knowledge of photographic crystallography is being used in obtaining better pictures.

"A single motion picture examined under the microscope is found to be composed of tiny particles of silver which look like little masses of coke," he said. "These are derived from the crystals of silver bromide in the creamy white sensitive layer exposed in the camera, and there are more crystals on a square inch of the film than there are human beings on the surface of the globe.

"Recently, scientists have determined how the atoms build up the crystals and have measured their sizes and shapes in different kinds of film. By careful adjustment of his processes, for instance, the manufacturer includes a great range of sizes of crystals in his negative film, which enables the beautiful gradation to be obtained. A more uniform size of crystals in the positive film gives life and sparkle to the pictures."

The speaker explained how a chance impurity in the photographic chemicals has worked to the advantage of the picture-making professions. "The sensitiveness of the grains of silver bromide is increased by the presence of specks on them produced by an accidental impurity in the gelatin derived from plants eaten by animals from whose skins the gelatin is made. It contains sulfur, which reacts with the silver bromide and forms specks of silver sulfide on the crystals. Under light, this produces a trace of metallic silver and during development is a nucleus on which more silver deposits; finally, the whole crystal becomes silver. These grains of silver compose the picture projected on the screen."—*Science Service*

CHEMISTRY CONTESTS IN THE HIGH SCHOOLS IN CALIFORNIA

MARION TARBELL, SACRAMENTO JUNIOR COLLEGE, SACRAMENTO, CALIFORNIA

In 1914, the Southern California Section of the American Chemical Society originated the idea of a high-school chemistry contest and it was instituted in the spring of 1914. This contest has been conducted annually there since that time. John H. Norton, now a member of the Sacramento Section, was chairman of the committee that had charge of organizing the contest in the Southern California Section. The Sacramento Section initiated the contest in 1923, and since then it has been held in that section annually. The California Section, which is comprised of the members in and around San Francisco, ran the contest in their territory in 1925 and 1926 only.

The purpose of these chemistry contests in the high schools is to stimulate an active interest in chemistry and to point out to the high-school student that chemistry goes farther than his limited course in high school.

For the information of those who might be interested in trying the same thing perhaps a brief outline of the procedure would not be amiss. To solicit interest, a circular is sent out in the spring to the high schools. This circular gives the date, time, place of examination, and defines the size of the team. There is a blank at the foot of the circular to be filled out by the principal of the school. This includes the name of the school, name and address of the principal, signature of the chemistry teacher, and the number of students enrolled in chemistry.

During the last month of the school year the contest is held at the various high schools. A chemistry class enrolment of twenty-five or less requires a team of three and one additional team member for each additional twenty-five or less students. The principal conducts the examination in his school.

The day before the examination he receives a sealed package containing the examination questions which have been made out by the committee. At the hour of the examination the seal is broken in the presence of the contestants, and the examination is started. The students are allowed three hours for the examination. At the time fixed for closing the examination each student seals his answers in an envelope which is provided for this purpose and signs his name across the seal. The principal countersigns all examinations, seals them in a larger envelope, and returns them to the committee in charge. The only means of identification on the paper is a number which is registered with the student's name, so that the grader has no way of knowing whose paper he grades. The committee grades the papers, averages the percentages of each team, and declares the winning team and highest individual.

A school trophy and a trophy for the highest individual are the awards made by the committee. These trophies, properly engraved, are given to the winning school. The school keeps them one year and returns them to the committee. After one school wins either trophy three times it becomes the permanent property of that school.

The fact that so far, in the Sacramento Section, no school has won the trophy more than one year shows that competition is keen and that interest has been aroused.

Chemist Refuses to Worry about World's Food Supply. The specter of starvation pressing on an over-populated world is something the chemist refuses to worry about. Economists and sociologists have concerned themselves over the population problem ever since Malthus worked out a statistical expression of it over a century ago, but they always assume unchanging needs and tastes on the part of the population, and unchanging methods for the production of food.

At the recent meeting of the Institute of Chemistry of the American Chemical Society, Dr. H. E. Barnard of Indianapolis challenged these assumptions, and declared that the chemist will be able to meet the food problems of any imaginable future population. The only thing that can limit the race is sheer lack of standing room, he said.

"The sociologist and economist study the Malthusian doctrine very differently from the chemist," Dr. Barnard continued. "They would limit world population to the number of people who can live happily and comfortably under the best living conditions today. The chemist is not so much interested in ideal living conditions as in applying scientific law to do the work of the world, no matter whether it is concerned with shelter or food or comfort.

"The chemist is impatient when he hears the Malthusian doctrine discussed in terms of wheat acreage, or sugars, or fats, for he is confident that when the fertile acres of the earth do not produce crops sufficient for man's needs he can synthesize them in his laboratory. Indeed he is already doing it. When the need comes the chemist will convert the light of the sun and the nitrogen of the air into food for the human family. Thirty men working in a factory the size of a city block can produce in the form of yeast as much food as 1000 men tilling 57,000 acres under ordinary agricultural conditions. To the chemist the Malthusian doctrine is but the sad reflection of a pessimistic world." —*Science Service*

Chrome Ulcers on Increase. Chromium poisoning is definitely increasing as a result of the widespread use of chrome plating on automobile accessories, Dr. Jackson Blair of Cleveland has reported to the American Medical Association. Twelve cases in two separate plants have recently been found.

This disease, known since 1863, is characterized by the acute symptoms of a bad cold and by ulceration of the nasal membranes and of the skin. In the electroplating of automobile headlights, door handles, radiator shells, etc., a solution of chromic acid is used. In the process, a fine spray of chromic acid is given off. This enters the nose of the workers, who also get the acid on their hands in removing the articles from the bath.

Cases of this disease have been noticed previously among workers in pigments and dyestuffs, photography, and the manufacture of colored glass.

An efficient ventilating system and long rubber gloves are found to be adequate preventives. Smearing the inside of the nose with petrolatum also helps.—*Science Service*

TEACHING OF COLLEGE CHEMISTRY

W. S. HALDEMAN, MONMOUTH COLLEGE, MONMOUTH, ILLINOIS

Much has been said and written, both favorably and unfavorably, about the content of and the methods employed in teaching college chemistry. Probably no new suggestion may be given in this brief paper. A reference to some salient factors, however, may give us a new impetus in the effort to stimulate our students toward reasonable originality and accomplishment.

More Originality to Stimulate Interest.—With all due respect for the tested and proved principles of sound pedagogy, we frequently come to places in our work, both in classroom instruction and laboratory direction, where originality within reason is the only wise course to take. Our text may be one of the best in every way but the class may not become highly interested if the teacher merely assigns and hears the author's viewpoint from chapter to chapter. The text can and should serve as a guide but cannot take the place of the vitalizing and stimulating influence of the trained and experienced teacher. No two teachers are exactly alike and no two chemistry departments are exactly alike in their equipment and purposes. We should therefore try to be ourselves and not someone else. If formulated theories of pedagogy keep us from interesting our students we should cut loose and try other methods, realizing that we have only one master pedagogue—the Universe with her unchangeable but fascinating laws of order, harmony, and progress. The eager student will soon realize that chemistry is the science that goes at the very heart of matter and energy to discover nature's laws and applies them for the welfare and progress of man in medicine and other sciences, in the arts and in the industries. Interest is certain to grow with the worthwhile student when he gets this viewpoint impressed upon him and sees on every hand the resultant progress of the application of these laws.

Recently, Irving Langmuir, on receiving the Perkin Medal, made some remarks that we as college teachers may well consider. This is what he said in regard to interest. "In looking back on my own school and college days, it seems to me that the things of most value were learned spontaneously through interest aroused by a good teacher, while the required work was usually uninteresting." What must be some of the characteristics of a teacher so that he may be able to arouse interest? We probably all agree that, granting a good personality is included, thorough training is one of the first requisites. Thorough training is not a static condition. A teacher might be thoroughly qualified for his duties on completing his graduate work, but in a few years he might not qualify as a thoroughly competent instructor because his training was not continual. Contact with the industries in their many applications of chemistry is another

requisite and will broaden our viewpoint and increase interest. Our students will benefit from our experience. This contact may be direct or indirect. The various industrial journals relating to chemistry give us this indirect contact. Visits to industrial plants during our vacations give more direct contact but best of all is the spending of some summers in the research laboratories of an industry. The research spirit is another essential for the wide-awake teacher. By carrying on some form of actual research we add fresh fuel to our enthusiasm and there can be no doubt that the students will benefit because of our greater interest in the work.

Contents of College Courses.—In another part of his acceptance speech Langmuir makes this statement. "Our schools and universities devote so much effort in imparting information to students that they almost neglect the far more important function of teaching the student how to get for himself what knowledge of any subject he may need." Most chemistry teachers agree fairly well on a general minimum of basic principles, theories, laws, and applications to be included in a college course. This general minimum content has been well discussed and summarized in the several numbers of the JOURNAL OF CHEMICAL EDUCATION during the last two years. All of us can glean valuable data, get suggestions, new viewpoints, and no little inspiration from a careful reading of these articles. Since the number of our students preparing for medical schools and graduate schools is increasing it is necessary to make our work fairly comprehensive and make it thorough in the fundamentals upon which later courses may be developed. College texts give a general outline of the content with varying degrees of stress on the different subjects. The individual teacher should use his own judgment as to what should be stressed or omitted or what additional work may be given or emphasized. Training to think and to do should be constantly kept in mind rather than a maximum content.

Methods.—The lecture method, for most of our work, has been found to give good results when followed with frequent short written recitations. Hour tests are also given at stated intervals. The papers are read, mistakes noted, and later these papers are returned to the student. Lecture-table experiments are probably among the most effective means a chemistry teacher can use in first-year work. Here we have the visual and other concrete factors to create interest. Instead of trying to master the preparation and properties of a given substance from the text the student will learn by observation. The student will also gain some ideas of laboratory technic from the lecture-table experiments.

Some subjects such as learning to write formulas and equations will require various methods—explanations, drill, discussions of principles involved, and quizzes to find out whether progress is made. Selected outside readings, exhibits from different chemical industries, and occasional motion pictures also form a part of the first-year course. A good list of

these pictures on the applications of chemistry may be secured from the U. S. Bureau of Mines, Pittsburgh, Pennsylvania. The first-year college course is not complete without definite laboratory work for the student. "We learn to do by doing" is a familiar statement. The purpose of the laboratory work is even more than this statement implies. Not only do we learn to do by intelligent doing but we actually *do* laboratory work so that we may learn more and acquire power.

Whatever the content or the method in college chemistry the teacher must be able to direct the student in the paths of reasonable theory and established facts. He should be able to instruct how to correlate facts and principles. He should thoroughly believe in his work. He should show enough enthusiasm so as to stimulate his students to the development of their powers.

Brownish Gasoline O. K., Chemists Declare. Discoloration in commercial motor gasoline does not necessarily mean poor quality, according to R. E. Wilson, research chemist of the Standard Oil Company of Indiana. Brown tints in the fuel, often plainly apparent to the customer served from modern glass dispensing apparatus, have no relation to possible damage which a fuel might do to a motor. On the contrary some very corrosive, low-grade gasolines are sparkling, "water-white" liquids.

Emphatic protest is voiced by Dr. Wilson against various obsolete tests and specifications which uninformed purchasers often demand of the oil companies, both on gasoline and lubricating oil. These demands, based on old-fashioned petroleum practice of a generation ago, are unreasonable, applied to the new modified motor products.

Specific gravity, once a critical measure of gasoline quality, now has almost nothing to do with merits in automotive use. In spite of this fact one state still demands a certain specific gravity test for gasoline sold in its territory, probably to the actual disadvantage of retail customers. Odor and color tests are equally wide of the mark.

With lubricating oils, flash-point, boiling-point, and various other tests have also grown obsolete, but customers continue to demand goods up to the so-called standard. Frequently, the fault lies with a shrewd salesman for a company which happens to have a reasonably good oil with some one particular high test. Much publicity is given to the numerical figures of this test. The test itself has nothing to do with the merits of the oil, but it does keep customers from wandering to other producers, none of whom happen to be able to meet it.

Large purchasers of petroleum products are urged to coöperate with competent chemists, now established with all reputable refiners, in an appraisal of the real merits of gasoline and oils on a modern basis, rather than to hold up a producer to unreasonable and useless tests.—*Science Service*

Hard Soap from Alligator Pears. Bureau of Chemistry and Soils, Department of Agriculture, announces that its chemists have devised practical means of using the oil from cull avocados (alligator pears). The oil obtained from the Fuerte variety of avocado by expression or solvent extraction has a dark green color by transmitted light and is red by reflected light. It is probably too dark for use as commercial edible oil although it has but little odor and a pleasant fruity flavor. The oil, when saponified, makes a hard soap. Tests indicate that the oil does not become rancid during a year's storage under ordinary conditions.—*Chem. Markets*, **23**, 202 (Aug., 1928).

WHY SURVEY?

WALDO W. SPEAR, BERNARDS HIGH SCHOOL, BERNARDSVILLE, N. J.

Educational surveys are not uncommon today. Why do school boards spend large sums of money for a survey of school systems? We who are in the business of education know that in the interests of economy and efficiency in the administration of the school plant the survey offers the same basis for intelligent procedure that it provides in any public or private enterprise, because when the facts that exist are discovered future ways and means can be sensibly and acutely established, recommended, and activated.

From this condition it follows that a wide and honest survey of any department of instruction in a given school building would set forth a host of facts relative to the work and management of said department of instruction which would be worth more than the effort exerted.

The survey ought to contain three major items: (*a*) the exposition of conditions as existing; (*b*) comparisons of individual facts with authoritative standards and with related conditions in similar schools; (*c*) a resumé of facts designed for use in aiding in the study of detailed problems. The author is prompted to write on this phase of teacher's work because he has recently completed a fairly intensive survey of his department in the new Bernards High School. The immediate results have been a distinct source of aid, especially in the requisition of new equipment, apparatus, and supplies. We have already begun work on a few detailed factors of instruction which, we are sure, would not have presented themselves without the searching implements of the survey. As an illustration of a few typical problems which are important in a township high-school science department such as ours, we might give the following: (*a*) What constitutes a good science library in a modern rural high school? (*b*) How much science ought to be required of pupils in a rural secondary school? (*c*) How may the physics course be amplified to meet more fully the interests of girls? (*d*) What are the criteria for evaluating the aims to be established in the laboratory from the college preparatory to the practical arts curricula?

The department survey should cover a period of several years. Within reasonable limits the accuracy obtained varies directly with the period of time under observation. At any event the survey should include a span of at least four years, so that one class can be viewed during its entire high-school existence. The study of our local investigation covered a period of seven years.

The data compiled should be reflected as far as possible from the group findings down to the individual pupil's measurements. In the first place, the survey ought to contain facts and comparisons relative to the general specifications of the science rooms. Even though you do not care to know

what percentage of the total floor area is given over to science instruction, you ought surely to have an inkling at least of what area, expressed preferably in per cent, constitutes a fair allotment of room desirable for the science activity; what studies, if any, have been made thereon which are analogous to the local situation. What specific ideas along this line would you recommend to your inquiring superintendent, who is contemplating a building program, when he interviews you relative to certain specifications for the new chemistry laboratory? Would you, for example, be able to inform him as to the number of fume hoods required? Or, if not possessed of the particular information requested, where could you find it? It may be that you keep a well-organized infallible card index. However, if you have conducted a survey, you will doubtless know what constitutes the optimum area per pupil in both lecture room and laboratory.

Secondly, are you in some degree conversant with the subject of ventilation and recommended proved systems? The point is this: by knowing how near to the recommended standards of floor area per pupil, of cubic feet of air space desirable per pupil, and of glass area ratio to floor area in both lecture room and laboratory your department provides, you will be more valuable in a building program situation and none the less important in other contingencies devolving upon the business of a science teacher. Reference 1 in the bibliography at the conclusion of this article is a recognized and established authority on high-school building standards.

Again, when a teacher knows the median number of library books in 1000 high schools for the science subjects taught, and also the number recommended by the N. E. A. Committee, he has a valuable guide to aid in filing his requisition for new books. Reference 2 in the bibliography at the end of this article provides very adequate information concerning library book selection for high schools of various enrolments.

The cost of equipment and furnishings for the science department is another factor that a survey should include. Such items as laboratory tables, chairs, fume hoods, filing cabinets, projection apparatus, etc., figured in terms of cost per pupil space, are necessary especially in matters previous to a new building feature. The amounts recommended for chemistry, physics, biology, and general science apparatus and materials together with statements of additional allowances for replacements, have been established. Reference 3 in the bibliography is an objective study of this feature.

A statement of the science curriculum and sequence, with a study embodying the extent to which it is recognized by the pupils, is very interesting and productive to the teaching staff involved. Equally illuminating is the gathering of figures to show the distribution of the science enrolment by grades and sex. Does your enrolment compare favorably with the fact that science subjects in 1922 registered 53 per cent of the students in all

high-school subjects? Or, again, what is the science enrolment compared to that of mathematics, foreign languages, and history, locally? Has the science enrolment increased proportionately with that of the entire school?

Again, what is the achievement of your department relative to standards based on teacher's marks as well as standardized tests? Is the accomplishment of boys greater than that of girls? What is the percentage of failures over a period of years? What is the holding power of the science courses? Why do pupils drop a subject? What is the teaching load and how does it compare with that in 136 city high schools whose average science teaching load is 568 pupil-hours per week?

These questions and others of like import can only be satisfactorily answered by a fairly detailed and accurate survey. After your particular local information has been gained, you are then equipped for the purpose of making comparisons with other localities with certainty. The" whys" and "hows" of many teaching problems can be more accurately established, remedial methods can be devised and executed more appropriately, preventive means can be instituted more confidently and expertly, new teachers coming into the department with some or no experience will become adapted more effectively both for themselves and for the department, and, summarily, teachers will be rendered more valuable to their immediate vocation because they will know a little more of the situation whereof they are a part.

References which proved very helpful in our survey work follow:

1. Strayer and Engelhardt, "Standards for High-School Buildings," Teachers College Publication, **1924.**

2. Glenn, "Past and Present Practices in High-School Library Book Selection from the Viewpoint of the Science Teacher," *School Science & Mathematics* **21,** 217–37 (1921).

3. Monahan, "Laboratory Layouts for the High-School Sciences," Bureau of Education, *Bull.* No. 22, **1927.**

4. N. E. A. Dept. of Superintendence, "School Buildings," Exhibits of 1922 and 1923.

5. "Some Data Relating to Chemical Education in the United States," THIS JOURNAL, **4,** 911–3 (July, 1927).

6. Ayers, "School Buildings and Equipment," Cleveland Educational Survey Report, 1916.

7. Donovan and Others, "School Architecture," Chap. 18.

8. N. E. A., "Report of Committees on High-School Libraries," 1918.

9. Bureau of Education *Bull.* No. 20, **1920,** "Reorganization of Science in Secondary Schools."

10. Bureau of Education, *City School Leaflet* No. 9, June, **1923,** "Teaching Load in 136 City High Schools."

11. Strayer and Engelhardt, "School Building Problems," Teachers College Publication Bureau.

12. Engineering Dept. of National Lamp Works, Nela Park, Cleveland, Ohio.

THE WORK OF THE EXCEPTIONALLY GIFTED STUDENT IN CHEMISTRY AND CHEMICAL ENGINEERING*

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This subject may be considered under two headings—first, as a general educational problem—second, as a problem in connection with education in chemistry and chemical engineering. I shall first consider the matter under heading one.

The time allotment in the college course given to class work, laboratory work, and study, is generally made on the basis of the *average* student. The upper ten per cent of unusually gifted students, and the lower ten to fifteen per cent of students who for one reason or another find their work difficult, require special treatment. The remainder of the average class, constituting something like three-fourths of the total, is usually taken care of without special treatment.

While this is the general status, there is considerable variation in practice. To a large extent the content of the subject and the standard of achievement is fixed by the individual professor and, at least from the standpoint of the student, courses may be divided into three classes as follows: (*a*) *Stiff courses.* The standards are fixed by the ability of the upper ten per cent of the class or in a few cases by the ability of the professor who persistently overrates the ability of his students and demands that they all come up to an unusually high standard. (*b*) *Easy or snap courses.* The standards are fixed by the ability of the lower ten per cent of the class or in some cases by the ability of the professor who is not brilliant and who carries on his work according to the methods which he himself pursued, possibly as a student. (*c*) *Well-balanced courses.* The standards are fixed by the medium third of the class. Let us hope that most of our courses as given belong to class *c*.

It is of course true that some subjects are inherently more difficult than others and some are relatively easier but it must be admitted that efficient teaching would require that any such inherent difference in individual subjects should be equalized by the time allotment or method of presentation; that is, that in relatively easy subjects the student should be called on for a great deal of work, while in the difficult subjects a good deal of help should be given by the professor.

It is also true that courses may be divided into these three classes according to the relative ability of the student. This in general produces the following results particularly with reference to able students:

(*a*) In the stiff course the able students pass the course and have plenty to do. In other words, the stiff course is ideal for the able students. For

*Read at the Greater New York and Northern New Jersey Section of S. P. E. E. Meeting at Princeton University, Princeton, N. J., Saturday, May 14, 1927.

this class of students all courses should be "stiff courses." The students of average ability have difficulty in passing and there are numerous flunks in the course resulting in repetition and discouragement on the part of the less able students.

(*b*) In the easy or snap course the able students loaf, seldom or ever study, get little of educational value out of the course, the reason for taking such courses being to acquire credits toward getting degrees. There are few flunks in such courses and possibly they serve to encourage the lower ten or fifteen per cent of the class, give some discipline to the average students, and for this reason are justified.

(*c*) In the well-balanced course the able students do not put forth their greatest effort and do not acquire the educational discipline to which they are entitled. Such courses are very satisfactory for the average student, undoubtedly are for the greatest good to the largest number, and for this reason the giving of such courses is justified. But it leaves the problem unsolved as to how the able student should be taken care of and this is the question which has been suggested for discussion at this conference.

The situation with reference to the college, whether cultural or technical, is complicated and made more difficult so far as the exceptional student is concerned by general educational conditions in the United States. College education has become popular with us, and is within the means of a large number of people because of the widely diffused material prosperity in our land today. We encourage and commend the self-supporting college student. This does not seem to be true in Europe where the college is run to produce gentlemen, members of the leisure class. We have three times as many college students in proportion to population as the colleges do in Europe. We get a larger proportion of students from homes without good educational background. Our students in many cases do not have the natural endowment which is possessed by those coming from a different class of the population. It is of course true that in the aggregate we get in our classes a larger number in proportion to population of exceptionally gifted students because we make it easy for the talented son of a poor man to get a college education as well as offering education to the sons of the well-to-do. While it may be true that in proportion to numbers there are fewer talented sons of poor men than come from families of the higher classes of society, still the numbers are so great in the lower class that we undoubtedly conserve to a much greater degree the occasional boy of ability. I believe this is one of the reasons for our great national prosperity.

Possibly out of sympathy, we have lowered our educational standards in order to educate as many as possible and also to secure the benefits of education to all, but that emphasizes all the more the need of making special provision for the student of exceptional ability.

Under conditions as they are, the result with reference to the exceptional student is that: these young men soon learn that the best policy in college is to maintain a fairly high average in all courses as no adequate reward is usually held out for exceptionally high-class work in a few subjects. He, therefore, works hard enough in subjects for which he does not have unusual ability to make good grades but does not do the best work of which he is capable in subjects for which he has the greatest talent. This system produces men of all around development but does not develop men of exceptional ability. The poor student is trained up to the average while the unusually endowed man is leveled down.

The question before us today is whether it would not be worthwhile to develop the unusual powers of the exceptional man—produce geniuses by our educational process as well as average men. This would involve, you will object, producing a lopsided man who may know a great deal of mathematics but no language, or a great deal of science but no history. This is inevitable because some subjects must be neglected if others receive undue emphasis. Education has been defined as the development of one's mental powers. Why neglect the most promising while putting forth great effort to develop ability along lines where only the most mediocre results may be expected?

Please note that I am not arguing for the average student nor for the dull student but for the relatively few exceptionally gifted students whose unusual endowments if cultivated might develop into genius. We have plenty of mediocrity. Outstanding pioneering leaders are all too few. I know you will answer that the all-around man should be developed. Let me answer that only a generation ago the college course was not much better than a first-class high-school education of today. We demand twelve years of education ending with the high school before admission to college. It would seem that we could well afford to provide special instruction in college for the relatively few who have the natural endowment fitting them to do exceptional work.

It might be admitted that such a plan would be feasible for cultural study but not advisable in the technical school. Here the student is fitting himself for professional work and the curriculum presumably includes only subjects essential to the future work of the student so that it would not be possible for the student to omit any of the prescribed courses and concentrate on others.

A study of chemistry and chemical engineering courses as offered does not sustain this point of view.

In a study, made by the Committee on Chemical Engineering Education of the American Institute of Chemical Engineers headed by Arthur D. Little, of the courses given in 78 institutions offering courses in chemical engineering, it was found that these courses included 210 separate subjects

in the various institutions. There would seem to have been few college courses not required by some institutions as a preparation for work in chemical engineering. The Committee found it exceedingly difficult to see why Irish history, zoölogy, Italian, Latin, or Greek should be required as a preparation for work in chemical engineering. While more agreement was found on fundamental courses, undoubtedly a very large proportion of the courses were added for reasons other than preparation for future work in any specific sense. The student might be given a very wide choice from this range of subjects without materially injuring his preparation for his chemical engineering work.

It might be thought that even in the fundamental subjects there would be no opportunity for modification, but the Committee was astounded to find that even here there was the widest variation in requirements. For instance, in such a fundamental course as general chemistry, the requirements as to hours were as follows:

General Chemistry	Maximum	Minimum	Average
Lecture	204	48	104
Laboratory	216	24	120

The subject which usually follows, namely, qualitative Analysis, was not treated any better, possibly worse, as is indicated in the following:

Qualitative Analysis	Maximum	Minimum	Average
Lecture	204	10	46
Laboratory	324	32	145

No doubt all of the 78 institutions studied turned out successful chemical engineers; in fact, we have many eminently successful chemical engineers who have had only partial courses in college or even none at all. One is at times tempted to conclude that some successful exceptional men would have been even less successful if they had been subjected to the leveling and pruning process of a college education. Some independent, strong minds cannot endure the restraints of college work. Some of these colleges might well be likened to the giant in the fable who fitted all men to the same bed by cutting off the legs of the long ones and stretching out the short ones.

These remarks must not be taken to imply that an educational program could not be developed which would still further develop the powers of the gifted student and make of a him a better chemist than he would be if he did not subject himself to the pruning process of our present college course. I have only intended to say that our present college courses do not provide adequately for the exceptional student and that we should in some way modify our courses for such exceptional men.

A successful career in the chemical field requires the ability to do original

work. In this respect the work of the chemist is almost unique. Such work can be done only by intense concentration on a given subject. Our most brilliant investigator, Irving Langmuir, brought out this point most forcibly in his Perkin Medal address.

It is for this reason that the author is firmly convinced that, as a preparation for a career in chemistry, thorough and exhaustive work along selected lines is the best possible form of preparation for the few who have the talent and initiative to do such work. He also does not believe in the sacredness of our curricula as laid out to the extent that the exceptionally gifted student might not omit quite a few of our present requirements and devote himself to courses in which he could do exceptional work to the great benefit of himself and the profession.

The small college generally offers the most favorable atmosphere for this kind of work. The machine of the big institution is apt to clip the wings of such ambitious spirits.

The faculty of the Polytechnic Institute of Brooklyn has, through one of its committees, made a study of the possibility of making provision for the exceptionally gifted student in the chemical engineering course and has decided to make a trial of a plan designed to do this for the coming year. The plan as outlined is wholly tentative and experimental. It is quite modest in its proposals, far from revolutionary, but if it shows some measure of success we are prepared to modify and change it in accordance with our experience in the endeavor to give the exceptional student an opportunity to develop along lines in which he has the greatest talent. The plan as outlined and adopted by the faculty is as follows:

1. The faculty shall each year select a number of students from among those completing their junior or senior years in chemical engineering who shall be eligible for honor work in their senior or 5th years.

2. The number of such students shall not exceed three in each of the four major departments of the school except by special action of the faculty.

3. All candidates shall be nominated by the department in which a student is enrolled.

4. Honor students shall consult the head of the department regarding the subject in which they wish to do honor work, which shall be assigned by the head of the department, and shall consist of semi-independent study or research beyond the requirements of the regular course.

5. The required work of regular courses may be wholly or partly replaced for honor students by the special work done at the discretion of the department.

6. The list of honor students shall be read at the annual commencement immediately following election by the faculty.

LECTURE DEMONSTRATIONS FOR GENERAL CHEMISTRY

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EQUILIBRIUM AND MASS ACTION

Principle Illustrated.—Cobalt chloride probably exists in solution in the hydrated form, the color of the solution varying with the degree of hydration as indicated by the following equation:[1]

$$CoCl_2.xH_2O \text{ (red)} \rightleftarrows CoCl_2.(x-y)H_2O \text{ (blue)} + yH_2O$$

At low temperatures the solution is red, due to the predominance of the highly hydrated red form. As the temperature is increased the equilibrium is shifted to the right and the solution becomes more and more blue in color, due to the predominance of the less hydrated blue form, *i. e.*, due to the partial dehydration of the highly hydrated form. Since the change in color is due to a shift in the point of equilibrium, *i. e.*, to a change from the highly hydrated red to the less hydrated blue, and since this shift is the result of dehydration, it should be possible to bring about a color change not only by increasing the temperature but also by adding a suitable dehydrating agent. Such a shift of equilibrium, first, by change of temperature and, second, by the addition of a dehydrating agent, can be demonstrated with the following experiments, both of which lend themselves readily to use in the lecture.

Experiments and Observations.—(1) Shift of equilibrium with temperature. Place about 200 cc. of a cold saturated solution of cobalt chloride in a test tube. The color is a cherry red. Pour about 150 cc. of this red solution into a second tube and heat to boiling. The color has changed to a deep blue. Pour the blue solution into a special test tube made by sealing off one end of a two-foot length of large glass tubing. Immerse this tube in an ice or ice-NaCl bath to a depth of about six inches, keeping the upper part warm by means of a Bunsen burner. The lower end will soon become red while the upper part will remain blue, illustrating, in a manner quite striking and impressive to the observer, the shift of equilibrium with change of temperature.

(2) Shift of equilibrium due to removal of water. Place about 200 cc. of a cold red solution of cobalt chloride in a convenient test tube. Add several pieces of anhydrous calcium chloride. The lower portion of the solution, with which the calcium chloride is in contact, soon turns deep blue while the upper part remains red. The color contrast is pronounced; and the result illustrates, quite convincingly, the shift of equilibrium due to a decrease in concentration of one of the products.

Remarks.—Since the student will already have been familiarized with

[1] Howell, *J. Chem. Soc.*, **1927**, 158.

the facts relating to hydrated salts and the dehydrating property of anhydrous calcium chloride he should have little difficulty in seeing the application of the principles involved in this set of demonstrations. The fact that the same substance is used in both experiments should help emphasize the point that a given equilibrium may be shifted in more than one way.

INVERSE SOLUBILITY-TEMPERATURE DEPENDENCY

Principle Illustrated.—As a general rule the solubility of a solid in a liquid increases with increase in temperature. There are numerous exceptions to this rule, a notable one being that of cerium sulfate whose solubility in water decreases from 19.09 at 0°C. to 4.78 at 50°C. to 0.78 at 100°C. The decrease in its solubility with increase in temperature is so great that it can readily be demonstrated as follows:

Experiment and Observations.—Place 100 to 500 cc. of an aqueous solution of cerium sulfate ($Ce_2(SO_4)_3$), saturated at zero, in a round bottom flask. Heat to boiling. A mass of crystals will precipitate out.

Remarks.—Since cerium sulfate dissolves very slowly in water at low temperatures the experiment does not lend itself to the illustration of the increase in solubility with decrease in temperature.

Country Has 137 Medicinal Trees. Of the 1177 different kinds of trees that are found in the forests of the United States, 137 have special medicinal virtues, Prof. Ernest F. Stuhr of Corvallis, Oregon, recently told members of the American Pharmaceutical Association at their annual meeting at Portland, Me. Prof. Stuhr has made a comprehensive investigation of all the trees in the country which are now or may be of medicinal value.—*Science Service*

Creosoted Ties Last Many Years. Thoroughly impregnated with creosote, railroad ties have an indefinite life on street railway lines even when the wood used is not of a kind that is ordinarily considered as resistant to decay, according to the U. S. Forest Service. Thus in Atlanta, Ga., creosoted ties of southern pine are in good condition after 31 years of service. The average life of creosoted ties of lodgepole pine and fir used by the city of Denver is 19 years. Minneapolis has installed some 200,000 treated ties since 1907 with few replacements. Treated ties installed there in 1917, recently removed on account of reconstruction, were found to be in such good condition that they were again placed in service while untreated oak in the same track and installed at the same time had to be scrapped.—*Science Service*

Synthetic Ephedrine Compared to Natural. Synthetic ephedrine has little difference in action from the natural product made from the Chinese herb Ma Huang, announced Dr. K. K. Chen of the Johns Hopkins University, at the recent meeting of the American Pharmaceutical Association at Portland, Me.

Dr. Chen reported the results of investigations on this drug which is used extensively to relieve hay fever and asthma, to dilate the pupils of the eyes before examination, and to contract congested membranes of the nose. Qualitative and quantitative tests indicate that the two drugs have almost the same properties. In the treatment of asthma, the synthetic drug appears to have a weaker action than the natural. In the effect on the membranes of the nose the two products are similar.—*Science Service*

AN IMPROVED HOT-WIRE GLASS CUTTER

J. ALLEN BAKER AND HARRY H. HALDEMAN, SIMPSON COLLEGE, INDIANOLA, IOWA

Inspired by the difficulty encountered by students of elementary chemistry when doing an experiment which required an 8-inch test tube with rim cut off, the authors sought for some means of cutting glass tubing other than the triangular file method. Various glass cutters of the hot-wire type were considered, with the result that a piece of apparatus was assembled which combined the better features of several instruments, such as portability, simplicity of operation and construction, low cost, and wide applicability. The authors wish to claim no credit for discovering a new principle or inventing a new apparatus. The hot-wire glass cutter has long been used in many institutions, and its principle is familiar to all; but we have never seen such an instrument which combined portability, simplicity, and general usefulness to a like degree.

Construction

The apparatus is assembled upon a base of asbestos composition board ("Transite") 12 × 24 inches in size. To support this base, No. 1 one-hole rubber stoppers (*K*) are slipped on stove bolts passing through holes in the four corners. The resistance coil *D-E* is wound upon a 3 × 6 inch piece of Transite which is fastened to the base by stove bolts and separated from the base by a tap or washer on each bolt between the two parts. The wooden trough *G-H* (made in two pieces), acting as a support for the article to be cut, is also bolted to the base, and has the end nearest the hot wire covered with asbestos paper which may be glued on with water-glass. *F* represents a single-contact knife switch, arranged so as to work very easily—at a touch.

The hot wire *A-B* consists of about 18 inches of No. 21 American Standard Gauge Nichrome wire, attached at *A* and *B* to binding posts. The post at *B* is screwed into a wooden handle, which may be made conveniently from a broom stick. The resistance wire *BCDE* consists of about 130 inches of No. 18 A. S. G. Nichrome wire, the length varying between certain limits to be given later. *B-D* should be long enough to allow plenty of slack wire for easy manipulation of the handle *B*. At *C* the wire passes through a hole in the base, going along the lower side of the latter until it reaches *D*. The remainder of the resistance wire is wound upon *D-E*. The apparatus operates on 110 volts, a. c. or d. c.

Operation

A piece of glass to be cut is first scratched lightly with a triangular file at the point where the break is to be made. This scratch need not be deep, nor does it need to encircle the glass. With very large tubes it is some-

times best to make two scratches on opposite sides of the tube, but this is seldom necessary. After being scratched the tube is laid in the trough *G-H* and a loop of the wire *A-B* drawn around it. The scratch on the tube should be on top, while the crossing of the two branches of the loop is below. Adjusting the position of loop and wire so that the loop is directly over the scratch, with the right hand the operator holds the wire *A-B* taut by means of handle *B*, meanwhile steadying the glass with the other hand and turning on the current by closing switch *F* with one finger. The wire *A-B* becomes red, and in a very short time the tube cracks under the loop.

There are two precautions to be observed: first, that the hot wire is not stretched too tight and, second, that the two branches of the loop are not

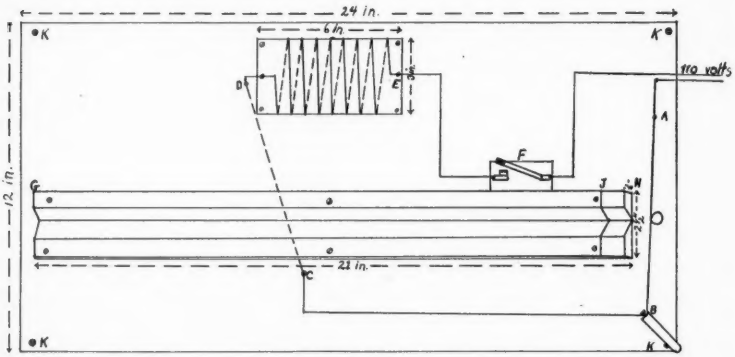


DIAGRAM OF HOT-WIRE GLASS CUTTER

A-B—hot wire, 18 in., #21 A.S.G.
B-C-D-E—resistance wire, 130 in., #18 A.S.G.
C-D—wire runs on lower side of base
D-E—17 turns (102 in.) resistance coil (base of Transite)
F—single contact knife switch
G-H—wooden trough
H-J—asbestos paper covering end of trough (water glass used for glue)
B—wooden handle, binding post in end
K—#1 rubber stoppers attached by stove bolts for supports

allowed to touch while the current is turned on. Should either error be made, the wire will break, hence it is well to have one or two extra wires cut, and perhaps attached to the bolts *K* on the under side of the base for safe-keeping.

In cutting very large pieces, such as large bottles, the glass is scratched as usual, but instead of encircling the bottle, the wire—with loop straightened out—is laid across the top of the glass, and the current turned on until a crack is made. The bottle is then rotated a little and the process repeated until the crack extends around the bottle, when a gentle tap will break the glass along the crack. In this way almost any size bottle may be cut off.

The apparatus described above has been found useful about the laboratory for cutting off test tubes, large tubing, broken condensers, bottles, and other things. Of course, it cannot be used with Pyrex glass.

In assembling the cutter, a little difficulty may be experienced in getting the right proportion between the relative lengths of the resistance and the hot wires. The dimensions given above were found by trial and error to be effective, although some other lengths may do just as well. An improvement recently made is a new handle with a built-in switch which may be operated by the thumb, leaving the left hand with only one function to perform—that of holding rigid the article being cut. However, it is hardly possible for everyone to obtain such a switch, lacking good shop facilities, while the simple knife switch is obtainable anywhere, and performs very well.

Forest Fires Destroy Natural Fertilizer. The toll collected by forest fires is not levied merely in terms of timber destroyed and game killed, but also constitutes a draft on the plant food "on deposit" against the needs of future tree generations.

To take a single striking example, the U. S. Forest Service says, a ton of needles falls to the ground each year in red and jack pine forests of the Lake states. These needles contain many substances essential for tree growth. An analysis showed that an acre of this leaf litter contained about 50 pounds of ash, 11 of nitrogen, 10 of calcium, $2^1/_2$ of phosphorus, 3 of potassium, and 5 of sulfur.

One of the most valuable of these constituents is the nitrogen, which becomes available to the plants and trees of the forest if the litter remains undisturbed. When forest fires burn the litter, the nitrogen is driven off in the form of a gas and is lost to the soil. This loss is a serious one and is shown by a decrease in growth until the nitrate is again available, usually several years after the fire. To replace the nitrogen in the litter collected in one year on an acre of northern pine forest would require the addition of 70 pounds of sodium nitrate fertilizer, which would cost about $3.

The fertilizing value destroyed by a forest fire is greater than the value of one year's fall of needles because normally the forest floor bears the accumulated litter of three or four years. Thus the actual loss in the needles and litter alone from a single fire in these pine forests may easily be $10 or $15 per acre.—*Science Service*

Chemists Told of Rare Metal Uses. Tungsten, a few years ago so rare that it was a curiosity even to chemists, is now a household necessity and a household word. Its near relatives, tantalum, molybdenum, and columbium, while not so universally familiar, are now produced quite as readily, and are finding an increasing use in industry, Dr. C. W. Balke, of Highland Park, Ill., recently reported to the Institute of Chemistry of the American Chemical Society.

The handling of these metals on an industrial scale presents its difficulties, according to Dr. Balke. The melting points are among the highest known for metals, and in order to prevent oxidation during melting, the process has to be conducted in a vacuum or under an inert gas such as neon or nitrogen.

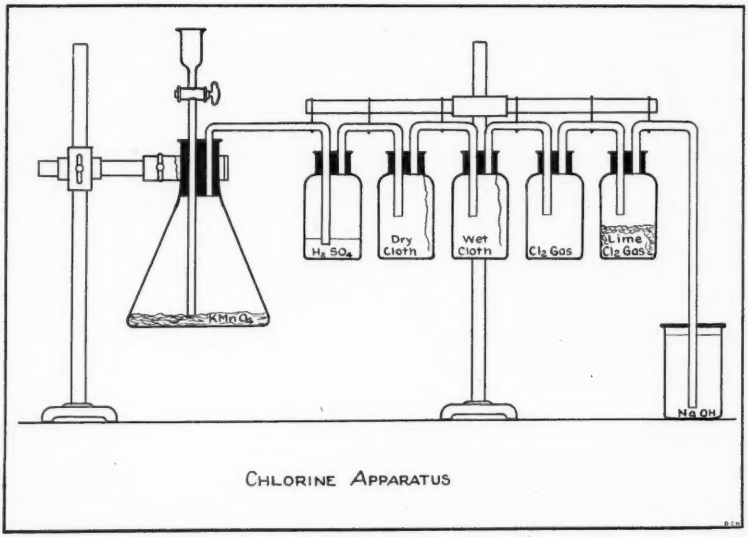
At the same session Francis M. Foley of Pennsylvania discussed the handling of various types of alloy steels. Some of the metals he described, designed especially for resisting corrosion, contain more nickel, chromium, and tungsten than they do iron.—*Science Service*

AN APPARATUS FOR THE PREPARATION OF CHLORINE

CHARLES H. STONE, ENGLISH HIGH SCHOOL, BOSTON, MASSACHUSETTS

The effects of chlorine upon the nasal passages and throat are so disagreeable and lasting that one approaches the study of the topic with a class with some dread. The usual method, as shown in our texts, consists of a generator and a train of receiving bottles standing on the table. With this arrangement it is difficult to remove one of the bottles without disarranging all the rest of the train. To obviate this difficulty, the apparatus shown by the annexed drawing was devised and has been used as a lecture-table experiment in our classes for a number of years.

As shown in the diagram the gas is prepared by dropping concentrated hydrochloric acid upon potassium permanganate crystals. The chlorine



CHLORINE APPARATUS

is passed through a drying agent and then enters a chain of bottles suspended from a horizontal support as shown.

The first receiving bottle after the dryer contains a piece of dry, colored cloth; the second contains a piece of the same cloth wet with water; the third bottle is left empty; the fourth contains some fresh slaked lime to form bleaching powder; finally the delivery tube leads down into a beaker of sodium hydroxide solution so that any possible trace of the gas is there absorbed. After the difference in the effect of chlorine upon the dry cloth and the wet cloth has been observed and explained, the chlorine in these

two bottles and in the third chlorine bottle may be utilized for the combustion of such substances as: warm copper foil, warm antimony powder, warm steel wool, turpentine on a strip of filter paper, or any other substances which will show the high chemical activity of chlorine at ordinary temperatures.

Any bottle can be removed by a simple turn and another bottle quickly substituted in its place, the removed bottle being instantly covered with a glass plate. In this way one can hardly notice the odor of the gas in the lecture room after the hour is over. If the bottles are turned on the rubber stoppers firmly, the friction is sufficient to keep each bottle in position when any one of the bottles is removed; there is no disturbance of the rest of the bottles in the train. We have never had a bottle drop off from its stopper due to excessive weight or insufficient friction.

In the generation of the chlorine, no heat is needed, for the action proceeds readily of itself. This method of preparation is by far the best when only small amounts of the gas are required, as would be the case in a lecture experiment.

If the lecture desk is equipped with a good fan and down draft there will be little odor of chlorine apparent, but even without these the method illustrated is a more convenient one than that of having the bottles stand on the top of the desk in the usual manner.

AN EDUCATIONAL FABLE*

There was once an Old Teacher who went to Summer School at a University which shall be Nameless. She was what used to be called a Born Teacher; by which is meant that on the first day her Classes realized that she knew more than they did; on the second day found that she knew more than the Book they were studying; and after that there was no more trouble, except the trouble they had in keeping up with all she made them do. When she had got through with them, even the Parents knew that their Offspring had learned something.

At the Summer School, the Old Teacher read Thornworth and Patrick and Wooddike and Kilroush, and spent seven weeks studying Foundations of Method—much the same as if a steam riveter were to study the Properties of Pig Iron. But she learned to call things she had already known about by New Names, and in the Learned Professions that is a Help.

Moral: *Terminology is half the battle.*

* "Educational Fables," Edward C. Durfee, *Scribner's*, **84**, 329–33 (Sept., 1928).

Education and Society. Education is the indispensable means by which society shapes its ends and determines its progress. It is the function of the teacher to interpret the past, preserve the present, and determine the future. It is impossible to capitalize society so strongly that its accumulated moral strength will not subside and ultimately end in bankruptcy unless its strength is renewed in each generation. That means that every generation is faced with the necessity of saving society.—*Daniel L. Marsh*

MOTION PICTURES FOR SCIENCE CLASSES

Motion Pictures Shown at the A. C. S. Institute, Evanston, Illinois July 23 to August 18, 1928

Number of reels, where known, given in parentheses ( ). Each reel requires about 15 minutes for showing. All films in this list are of standard width, 35 mm., but some may also be obtained in the 16 mm. width.

General Electric Company, Visual Instruction Service, 230 S. Clark St., Chicago, Illinois; there are several branches in other cities. *Beyond the Microscope* (1); *The Sugar Trail* (*Beet Sugar*) (1); *Liquid Air* (1).

Y. M. C. A. Motion Picture Bureau, 1111 Center Street, Chicago, Illinois; there are several branches in other cities. Catalog available. *The Story of Compressed Air* (2); *The Story of Bakelite* (2) (not shown); *Inside Out* (Story of Digestion in Animated Drawings) (1); *Terra Cotta* (1).

E. I. du Pont de Nemours and Company, Publicity Bureau, Wilmington, Del. *Letting Dynamite Do It* (1); *The Story of Dynamite* (2); *Building New York's Newest Subway* (1).

U. S. Department of Agriculture, Motion Picture Laboratories, 1363 C Street, N. W., Washington, D. C. *What's Ahead* (2); *Profits from Cull Oranges and Lemons* ($1^1/_2$); *Dust Explosions* (1).

Suchar Process Corporation, 72 Wall Street, New York, N. Y. *Cane Sugar Manufacture* (2).

William J. Ganz, 507 Fifth Avenue, New York, N. Y. *Fyre-Freez Extinguisher* (1).

Forest Products Laboratory, Madison, Wisconsin. *Wood Wisdom* (1); *A Forest Axiom* (1).

Synthetic Nitrogen Products Corporation, Agricultural Department, 285 Madison Avenue, New York, N. Y. *Making Air-Nitrogen in Germany* (2).

Carborundum Company, Niagara Falls, N. Y. *The Jewels of Industry* (6).

American Chemical and Potash Corporation, 233 Broadway, New York, N. Y. *Extraction of Potassium Salts from Searles Lake* (2).

The Viscose Company, 171 Madison Avenue, New York, N. Y. *The Romance of Rayon* (2).

Eastman Kodak Company, Kodak Park Works, Rochester, N. Y. *The Growth of Crystals* ($^3/_4$).

American Rolling Mill Company, Middletown, Connecticut. *The Manufacture of Armco Ingot Iron* (2 and 4).

The Barret Company, Agricultural Department, Medina, Ohio. *The Manufacture and Use of Ammonium Sulfate* (2).

U. S. Bureau of Mines, 4800 Forbes Street, Pittsburgh, Pennsylvania. *The Story of Sulfur* (2); *The Story of the Storage Battery* (2); *The Story of Petroleum* (7); *The Story of the Fabrication of Copper* (2); *The Story of a Spark Plug* (2); *The Story of Portland Cement* (1).

Armstrong Cork Company, Linoleum Division, Lancaster, Pennsylvania. *Linoleum Manufacture* (2).

Carpenter-Goldman Laboratories, Inc., 161–179 Harris Avenue, Long Island City, N. Y. *Electric Measurement* (5).

Standard Oil Co. of Indiana, Engine Laboratory, Whiting, Indiana. *The Mechanism of Lubrication* (1) (not shown at Institute).

Heinz Rosenberger, Rockefeller Institute for Medical Research, 66th Street and Avenue A, New York, N. Y. *Colloids* (2) (not released in time for Institute showing).

Save the Surface Campaign, 18 East 41st Street, New York, N. Y. *The Romance of Paint and Varnish* (4).

E. R. Squibb and Sons, Pharmaceutical Division, 80 Beekman Street, New York, N. Y. *Sunshine from the Sea* (3).

Malcolm MacFarlane, New York Central Lines, 466 Lexington Building, New York, N. Y. *The Mining and Preparation of Bituminous Coal* (2).

Milwaukee Sewage Commission, 508 Market Street, Milwaukee, Wis. *The Milwaukee Sewage Disposal Plant* (2).

Parke, Davis and Company, c/o Chief Chemist, Detroit, Michigan. *The Manufacture of Biological Products* (2).

U. S. Chemical Warfare Service, War Department, Washington, D. C. *Peacetime Activities of the Chemical Warfare Service* (2).

International Paper Company, Park Avenue and 42nd Street, New York, N. Y. *Paper* (6).

International Harvester Company Advertising Department, 606 South Michigan Avenue, Chicago, Illinois. Catalog available. *The Making of Steel* (2).

Additional motion pictures of interest to chemists (including some of those shown at the A. C. S. Institute, State College, Pennsylvania, July 5 to 28, 1927)

Carpenter-Goldman Laboratories, Inc., 161–179 Harris Avenue, Long Island City, N. Y. *The Principles of Magnetism* (2); *The Principles of Electrostatics* (2); *The Principles of Current Electricity* (2); *The Principles of Electromagnetism* (2); *The Principles of Current Generation* (2).

National Tube Company, 1802 Frick Building, Pittsburgh, Pennsylvania. *The Arteries of Industry* (Manufacture of Steel Pipe) (5).

Eastman Kodak Company, Kodak Park Works, Rochester, N. Y. *A Trip through Filmland.*

Ontario Bureau of Mines. *Mining Nickel and Copper Ores* (1).

G. H. Mead Company, Dayton, Ohio. *From Spruce to Newsprint* (7).

Educational Film Exchange, 829 S. Wabash Avenue, Chicago, Illinois. (Films for rental or sale only.) Catalog available. *The Ant; The Mosquito.*

General Electric Company, Visual Instruction Service, 230 S. Clark St., Chicago, Illinois. Catalog available. *The Conductor* (Manufacture of Lamp Cord); *Big Deeds; Wizardry of Wireless; Our Daily Bread.*

International Nickel Company, 67 Wall Street, New York, N. Y. *The Manufacture of Nickel.*

Certainteed Products Corporation, 100 E. 42nd Street, New York, N. Y. *From Rags to Roofing* (1).

U. S. Bureau of Mines, 4800 Forbes Street, Pittsburgh, Pennsylvania. Catalog available. *Copper* (2); *Oxygen the Wonder Worker* (2); *The Story of Asbestos* (4); *The Story of Heat Treatment of Steel* (2); *Fire Clay Refractories* (4).

Hammermill Paper Company, Erie, Pennsylvania. *The Manufacture of Paper.*

Y. M. C. A. Motion Picture Bureau, 1111 Center Street, Chicago, Ill. Catalog available for many interesting films on varied topics.

E. I. du Pont de Nemours and Company, Publicity Bureau, Wilmington, Del. *A Visit to the Nitrate Fields of Chile* (1).

Western Electric Company, Motion Picture Bureau, 120 W. 41st Street, New York, N. Y. Catalog available.

E. R. Squibb and Sons, Pharmaceutical Department, 80 Beekman Street, New York, N. Y. *The Preparation and Testing of Biological Products* (5).

Foamite-Childs Corporation, Utica, New York. *Use of Foam in Extinguishing Oil Fires* (5).

The Koppers Construction Company, Pittsburgh, Pennsylvania. *Operation of a Typical By-Product Coke Plant.*

The Educational Screen, 5 South Wabash Avenue, Chicago, Illinois. Catalog available: *"1000 and One, the Blue Book of Non-Theatrical Films"*—contains names, explanations, and distributors of all educational and non-theatrical films.

It may be of interest to add that the *News Edition of Industrial and Engineering Chemistry* for October 10, 1927, contained a list of all the films which were shown at the first A. C. S. Institute, State College, Pennsylvania, July 5 to 28, 1927.

The following film is a very important addition to those shown at the Evanston Institute: Ellice McDonald, University of Pennsylvania Medical School, Philadelphia, Pennsylvania. *The Growth of Living Tissue* (3).

Iron Wire in Acid Acts Like Nerves. A striking similarity between nervous action, particularly heart action, and the behavior of iron wire in a nitric acid bath has been discovered and studied by Ralph S. Lillie, professor of physiology at the University of Chicago. He has been working out the analogy for several years and it forms a significant part of his theories concerning nervous action which have been published in book form and, more recently, in *Science.*

According to A. J. Carlson, chairman of the department of physiology at the University of Chicago, the study of this similarity is of fundamental importance in the acquisition of knowledge concerning nervous action. "The obscure problems of physiology," said Dr. Carlson, "and the problems difficult to work out on experimental animals must be approached through study on easily controllable materials. The work of Dr. Lillie on the iron wire, because it yields results so similar to the observable phenomena in living nerves, is highly suggestive with reference to further research and ultimate knowledge.

The freakish behavior of pure iron wire in nitric acid has long been known but it was not until Dr. Lillie began his experiments that the almost startling similarity with living nerves was discovered. A popular demonstration of the experiment consists of a pure iron wire, 1 to 5 centimeters long, immersed in a bath of nitric acid of 60 to 80 per cent. A colorless film immediately forms over the wire. If the wire is scratched at one end, a wave travels rapidly along the wire. If a small glass tube is placed in the acid around one end of the wire, rhythmical waves pass the length of the wire at a rate of from 14 to 120 times a minute, depending on the strength of the solution, the temperature, and the length of the wire.

What happens, according to Dr. Lillie, is that a sort of battery is formed. The film, which is the thickness of only one molecule, has an electrical charge negative to that of the wire. When the film is scratched, a current sets up which dissolves the film next to the bare spot. This continues until the bare spot, which is seen as a wave, has passed the length of the wire. The film forms again after the wave has passed. The glass ring at one end of the wire establishes an area of permanent activity because the acid becomes less concentrated. Thus, as if the film were being continually scratched, rhythmical waves pass along the wire as rapidly as the film is re-formed. "The process may be regarded," says Dr. Lillie, "as a two-dimensional explosion."

The analogy to nervous action is emphasized by the effect which outside factors have upon the rhythm of the wire. The influence of temperature, electrical polarization, concentration of acid and length of the wire, have been shown by Dr. Lillie to be the same as the influence of these factors on living nerves.—*Science Service*

THE SWAMPSCOTT MEETING

Report of the Secretary of the Division of Chemical Education

The Senate of Chemical Education

9 A.M., Monday, September 10, New Ocean House. Wm. McPherson, presiding.

Present: A. A. Ashdown, R. A. Baker, Edward Bartow, A. P. Black, C. A. Brautlecht, J. S. Chamberlain, G. C. Coyle, H. W. Crouch, F. B. Dains, A. S. Eastman, R. E. Elderfield, A. B. Gordie, N. E. Gordon, F. M. Greenlaw, J. S. Guy, J. H. Jensen, J. T. MacKenzie, L. W. Mattern, R. F. McCracken, Wm. McPherson, H. W. Moseley, Rosalie M. Parr, Laura P. Patten, G. A. Perley, N. W. Rakestraw, E. E. Reid, W. Segerblom, E. M. Shelton, Owen L. Shinn, J. N. Swann, S. P. Sy, Geo. Thomson, H. L. van Klooster, R. C. Young.

The minutes of the April meeting were approved as printed in the May issue of THIS JOURNAL.

Revision of the Constitution and By-Laws.—L. C. Newell, *Chairman*, reported for this committee, which recommended that each member of the Senate be requested to answer by letter certain questions relative to membership in and dues of the Division and its relation to the Senate. It was voted to adopt the report and to continue the committee. In accordance with this action a series of questions will shortly be submitted to the Senate.

Organization.—N. E. Gordon reported upon his work of revising the list of Local Organizations of Chemistry Teachers, and clearly showed the need of defining eligibility for representation in the Senate. It was voted that each Local Section of the A. C. S., and such additional groups or associations as shall be approved by the Division of Chemical Education, shall be entitled to three representatives in the Senate of Chemical Education—one high-school representative, one college representative, and one industrial representative.

Journal of Chemical Education.—Wm. W. Buffum reported that there are now 9300 subscribers to the JOURNAL, of whom over 3000 are business men, while only 2500 are teachers. The JOURNAL carries 28½ pages of advertising. The coöperation of all Local Sections is needed to secure more subscribers. A rebate of $1.00 will be given for each new subscriber, or 30 cents for each renewal secured by a Local Section. The greatest problem of the business office at present is to obtain the names of high-school teachers of chemistry. Journals delivered to one address in lots of 100 or more may be secured for $1.00 each per year. It was voted to be the sense of the meeting that no effort should be spared to bring the JOURNAL to the attention of every high-school teacher and college teacher of chemistry.

Nomenclature.—A. P. Sy, chairman of the committee on nomenclature,

presented a report which was accepted and will be published in a later issue of THIS JOURNAL.

Women's Club Study Courses.—Harrison Hale, *Chairman*, reporting by letter for this committee, announced the receipt of a gift of $1000 from Mr. F. P. Garvan for the purpose of supporting the work of this committee. Work upon a course to be offered with the coöperation of the General Federation of Women's Clubs is now under way. Study of this course is to be undertaken by the individual clubs selecting it in the fall of 1929. A more detailed report will be made at the Columbus meeting next April. The report was accepted and the committee continued. The secretary was instructed to send a note of appreciation to Mr. Garvan.

Minimum Equipment for High-School Chemistry.—At the St. Louis Meeting J. H. Jensen was appointed chairman of this committee with a view to reorganizing it. He reported as follows:

> Your committee is being reorganized in order to secure men who are thoroughly acquainted with the needs of the small high school and who are also vitally interested in the problems of the small high schools. Several men have consented to serve on this committee and their names have been presented to the officers of the Division of Chemical Education for their consideration.
>
> The committee proposes to make such necessary corrections in the list which was presented at the St. Louis Meeting and published in June, 1928, issue of THIS JOURNAL (pp. 749–54). This part of the list then will be submitted to the Senate of Chemical Education for consideration. As soon as this part of the list has been disposed of, the committee will take up the problem of kind and grades of chemicals suitable for high-school work.

The report was accepted and the committee continued.

Order of Precedence of Laboratory Work and Recitation in High-School Chemistry.—F. N. Greenlaw, *Chairman*, reported the results of a questionnaire recently circulated by this committee. This progress report, which appears elsewhere in the JOURNAL (pp. 1300–6), was accepted and the committee continued, with instructions to put into operation the proposed experimental program in an effort to secure additional data.

Professional Spirit.—The committee was represented by its chairman, L. W. Mattern, who stressed some of the principal difficulties in arousing professional interest among high-school teachers of chemistry, such as: short tenure, inadequate pay, overloaded schedule, unwise teacher selection, and inadequate equipment. He pointed to the JOURNAL OF CHEMICAL EDUCATION as the most important means of reaching and inspiring the teacher. The report was accepted and the committee continued.

Local Secretary.—A. W. Taylor reported briefly upon arrangements for the Swampscott program of the Division. The plan of appointing a local secretary for each meeting has been abundantly justified since it has been in operation. Mr. Taylor received expressions of appreciation and thanks for his work.

Columbus Meeting

It was voted to hold a symposium on "Lecture Experimentation" at the Columbus meeting in April, 1929. It was the sense of the meeting that the Senate should not be convened on Monday or Thursday of convention week because of the inability of many members to be present on either of these days. It was suggested that the secretary try to arrange a breakfast meeting for the Senate at the next convention.

Adjourned, 11:45 A.M.

Meeting of the Executive Committee

5 P.M. Monday, September 10, New Ocean House. Wm. McPherson, presiding.

Present: R. A. Baker, N. E. Gordon, L. W. Mattern, Wm. McPherson, Rosalie M. Parr, and W. Segerblom.

Voted that the Division coöperate fully with the newly appointed A. C. S. Prize Essay Committee.

Voted that the financial report of the Division for each year be published in the JOURNAL as soon as practicable after Dec. 31st.

Adjourned, 6 P.M.

Departmental and Contributing Editors' Meeting

5 P.M., Tuesday, September 11, Deer Cove Inn. Policies of the JOURNAL OF CHEMICAL EDUCATION were discussed.

The Division of Chemical Education

4:30 P.M. Wednesday, September 12, New Ocean House. Wm. McPherson, presiding.

Present: R. A. Baker, C. A. Brautlecht, L. S. Howard, J. H. Jensen, A. R. Lincoln, L. W. Mattern, Wm. McPherson, W. B. Meldrum, Laura P. Patten, Rosalie M. Parr, F. J. Pope, W. Segerblom, A. P. Sy, A. W. Taylor, J. A. Veno, P. C. Voter, H. E. Wells.

Voted to approve the minutes of the Senate meeting of Sept. 10th.

The nominating committee, consisting of W. Segerblom, L. C. Newell, and N. E. Gordon, proposed the following names for the offices to be filled at this time: for chairman, Wm. McPherson; for vice-chairman, M. V. McGill; for treasurer, Rosalie M. Parr; for member of the executive committee, L. W. Mattern. There being no further nominations, the secretary was instructed to cast a unanimous ballot, and these officers were declared elected for a term of one year.

Voted that, in order to appear on the program of the Division of Chemical Education, papers must be submitted in full at least one month before the

meeting, exceptions to be made only in the case of special features which are solicited.

Adjourned, 5:45 P.M.

Program

Four sessions were devoted to the reading of papers and discussions, the detailed program of which will be found in THIS JOURNAL, **5**, 1014–6 (Aug., 1928). The symposium on The Teaching of Physical Chemistry attracted a capacity audience and was well received. The round table conference on Pandemic Chemistry, which occupied the last half-day session, was well attended. The general nature of the discussion at this conference has been made the basis of an editorial note in this issue of the JOURNAL.

Thirty members of the Division lunched together at the Deer Cove Inn Monday noon. Wm. W. Buffum outlined the problems confronting him as business manager of the JOURNAL, chief of which is that of reaching the high-school chemistry teachers in order to bring the JOURNAL to their attention. He received several constructive suggestions. Tuesday noon, at another luncheon at the same place, seventy members of the Division welcomed President Parr of the A. C. S., and a number of high-school chemistry teachers from the Northeastern area. Brief addresses were given by Wm. McPherson, C. H. Herty, N. E. Gordon, L. C. Newell, Laura M. Patten, J. H. Jensen, and Chas E. White, all on the subject of the forthcoming A. C. S. Prize Essay contest.

The meetings of the American Chemical Society carry immeasurable inspiration into every section which they visit. It is hoped that all teachers in the area will avail themselves of the opportunity to attend the Columbus meeting, April 29–May 4, 1929. Begin now to plan for future meetings: Fall of 1929 in Minneapolis; Spring of 1930 in Atlanta; and Fall of 1930 in Cincinnati.

R. A. BAKER, *Secretary*

ORDER OF PRECEDENCE OF LABORATORY WORK AND RECITATION IN HIGH-SCHOOL CHEMISTRY*

This report presents the results of an inquiry as to the position occupied by laboratory instruction in the teaching of chemistry in secondary schools. A questionnaire was formulated by a committee appointed by the President of the Division of Chemical Education. Replies were received from sixty-five schools in fifteen states, including New England, New York, Pennsylvania, Ohio, Illinois, Wisconsin, Michigan, Iowa, Indiana, and Kan-

* Committee progress report submitted to the Senate of Chemical Education of the A. C. S. at Swampscott, Sept. 10, 1928.

sas, with a total registration of 88,984 pupils. Seventy-one teachers of chemistry are represented. Of these teachers, three have no college degree, forty hold a bachelor's degree only, twenty-eight have a graduate degree, two report graduate study without a graduate degree. The average length of service in teaching chemistry is a fraction over thirteen years.

Registration.—The largest registration in a single school is 4900; the smallest 165. The average per school in this list is 1369. The whole number of pupils registered in chemistry is 9035. This is 10.15% of the total registration. This percentage, however, does not differentiate between senior high schools of three years and the four-year high schools.

Per Cent Taking Chemistry.—If, further, we remember that chemistry is offered only in the eleventh and twelfth grades (with one notable exception) and take as a base the number of pupils reaching these grades, those taking chemistry number 40% of the pupils who reach the grade in which it is offered. That is, two of every five who might study chemistry in the high school actually do so. If the base is further narrowed by excluding pupils registered in commercial courses, who ordinarily do not have the privilege of electing chemistry, the percentage of those taking the subject would be even greater. There is, however, a wide variation in the percentages reported from different schools. In one city high school in New England, 29.4% of all the pupils in the school study chemistry. Other high percentages, all from New England, are 28.5, 27.3, and 21.4. The lowest percentage reported, also from New England, is 2.2 but this is paralleled by a percentage of 3.1 from a large city high school in a north central state.

Grade in Which Chemistry Is Offered.—Chemistry is offered in the tenth grade of a single school, in the eleventh grade only of fifteen schools, in either the eleventh or twelfth grade of twenty-five schools, in the twelfth grade only of twenty-three schools. That is, forty out of sixty-four schools offer chemistry in the junior year, thereby reaching a larger number of pupils than if the election were restricted solely to the senior year. This is significant because it apparently indicates that in actual practice many pupils begin chemistry without previous study of physics, and are able to carry the subject successfully.

Length and Number of Periods.—The length of a single school period is decidedly a variable, ranging from forty to seventy minutes, with an average length of forty-six minutes. The number of periods allotted to chemistry is even more variable, ranging from four to ten, with an average of a fraction over six periods. The distribution of this time between recitation work and laboratory also fluctuates widely, ranging from one recitation period with four laboratory (single) periods to three single recitation periods with one laboratory exercise. On the whole, however, something

more than one half the total time is given to recitation and classroom work, in the ratio of six to five. Twenty-three schools (35% of the total) allot to chemistry three single recitation periods and two double laboratory periods. This distribution is more nearly standard than any other.

Flexible Program.—Fifty-one of the sixty-five schools reporting, have a fixed program with laboratory exercises occurring on stated days. This is without doubt due to the difficulty of arranging a flexible program in a large school with its complicated schedules. The writer comments here on the desirability of a more flexible arrangement under which the laboratory work can be more closely coördinated with the classroom study.

Textbook.—In regard to the textbook used, Brownlee and others lead the list with twenty-two adoptions; Black and Conant, 13; McPherson and Henderson, 9; Bradbury, 5; Dinsmore, 3; Smith, revised by Kendall, 3; Dull, 2; Gray, Sandiford, and Hanna, 2; and the following, one each: Emery, Davis, and others; Greer and Bennett; Irving, Rivett, and Tatlock; Newell; Smith and Mees. One school reports that no single text is used regularly.

Order of Laboratory Work.—In thirty-five schools, laboratory work comes regularly before discussion of the related text. In twenty-two schools, laboratory work follows the textbook discussion. The remainder reporting vary the procedure according to the nature of the topic. Thus, 55% of the teachers replying believe in the laboratory as a means of introducing the pupil to new topics.

Advance Preparation.—Only twenty-four schools, however, require any preparation in advance of the laboratory exercise, and but nineteen of these require any outside preparation. The present speaker is strongly of the opinion that, without previous preparation, pupils waste much precious time in getting started. If, on the preceding day, a few minutes are taken to state the laboratory problem in such a way as to arouse the anticipation and interest of the pupil, to connect it with the topic under discussion and to assign related paragraphs of the text for outside study, the pupil comes to the laboratory with definite purpose and some knowledge of the significance of the exercise. In addition, if he has studied the directions for procedure in advance and formulated an outline for his report so far as is possible, he is ready to begin without loss of time and is practically certain to complete the exercise within the limits of the laboratory period.

Demonstration Method.—In forty schools the teacher-demonstration method is used before classroom discussion takes place; in five schools demonstration work by the teacher follows the classroom discussion; three report that teacher demonstrations sometimes precede and sometimes follow the recitation, and sixteen reply that they are given at the same time.

Introduction of Descriptive Topics.—Twenty-six schools report that descriptive topics are introduced by the teacher-demonstration method.

Only six prefer the laboratory method as a means of introducing such subjects. Twenty-four use both methods. Four state definitely that they do neither, and five do not reply. It is indicated therefore that in 14%, or nearly one-seventh, of the schools reporting descriptive topics are assigned for study and recitation without previous experimental illustration by the teacher or laboratory experience on the part of the pupil.

Order of Laboratory Work and Recitation.—The statistics previously given will be justified if they present a picture of the actual situation in the high-school classroom and laboratory. The focus of this questionnaire, however, is upon the question "Which relative order of laboratory work and recitation gives best results?" The writer realizes that this is still a matter of opinion, owing to the lack of experimental studies leading to definite conclusions. It is felt however that the opinion of a large number of competent teachers should carry much weight in any evaluation of current methods of teaching chemistry. In direct answer to the question at issue, thirty-eight teachers reply that laboratory work should come first; nineteen favor placing laboratory work after the recitation, and one suggests that the order should vary according to the topic. In the proportion of two to one, however, the group of teachers circularized believe that best results are secured by having the laboratory study precede the classroom recitation.

In answer to the question, "Which method is more economical of the teacher's time and strength?" forty regard the recitation method as easier for the teacher; seven think the laboratory method is easier; one replies that it depends upon equipment and local conditions, and one very strongly asserts that *no* method of teaching high-school chemistry is economical of the teacher's energy and vitality.

As to which order presents the greater teaching difficulties, only a limited number hazard a definite opinion. Thirty-six say that the laboratory method (implying that the inductive method is used) is the more difficult; eight believe that the recitation method (implying deductive procedure) is more difficult; and five do not consider that one method presents more difficulties than the other.

Educational Values of Laboratory Method.—There is a rather surprising agreement of opinion in regard to educational values inherent in laboratory work which cannot be realized by the textbook-recitation method. The values emphasized are eight in number. They are listed in order of the frequency with which they are named, as follows:

1. Acquirement of manipulative skill (laboratory technic).
2. Concrete, or first-hand, knowledge through direct contact with the material studied.
3. Training in habits of accurate observation.
4. Cultivation of ability to reason and draw conclusions.

5. Development of initiative and resourcefulness.
6. Increased interest.
7. Training in habits of accuracy and neatness.
8. Appreciation of the scientific method of thinking.

Four direct quotations are appended to bring out individual differences of opinion. One teacher asserts that "a large amount of laboratory work is quite a waste of time." Another says, "It is not possible to teach chemistry in any other way." A third is "not convinced that there are many advantages" in the laboratory method, while still another believes that the laboratory method offers "nearly everything worthwhile."

Laboratory Topics.—Owing to their great diversity, it has been difficult to prepare a fair summary of the answers to question 26 (what topics should unquestionably be studied first in the laboratory?). Approximately fifty different topics were named, ten of which were each mentioned by four or more teachers. In order of frequency they are listed as follows:

1. Elementary gases.
2. Preparation and properties of important elements and compounds.
3. Acids, bases, and salts (including neutralization).
4. Physical and chemical changes.
5. Manipulation (including weighing).
6. Common metals.
7. Ionization (including properties of ions).
8. Chemical equivalents.
9. Law of definite composition.
10. Acid-forming oxides.

Each of the following additional topics was suggested by two or more teachers: electrolysis; replacement series; oxidation; solutions; hydrolysis; reversible reactions; halogen family; food analysis; gas laws; percentage composition. One teacher (from a dry state) believes that distillation should be taught in the laboratory. There is no information as to whether or not it is a common home project in his section.

It is interesting to note that three teachers believe that *no* topic can best be introduced in the laboratory, while five are convinced that *all* topics which do not involve manipulation beyond the capacity of the pupil should unquestionably be studied first in the laboratory.

Lecture-Demonstration Topics.—Approximately fifty topics were suggested which, in the opinion of teachers, are best suited for treatment by the lecture-demonstration method. Twelve of these were named by three or more teachers each. Listed in order of frequency of occurrence they are as follows:

1. Electrolysis.
2. Experiments involving the preparation of disagreeable or dangerous products, such as Cl_2, SO_2, H_2S, CO, Br_2, HNO_3.

3. Theory of ions.
4. Valence.
5. Illustrations of commercial processes such as contact process for H_2SO_4 and Solvay process.
6. Gas laws.
7. Atomic structure.
8. Quantitative experiments on equivalent, molecular, and atomic weights.
9. Law of mass action.
10. Reduction of CuO by H_2.
11. Experiments involving difficult manipulation or the use of costly apparatus.
12. Distillation (including fractional distillation).

It will be noted that only two topics are common to both lists, ionization and chemical equivalents. Thirteen teachers prefer to teach ionization by the demonstration method while five use it as a laboratory topic. Opinion is evenly divided in regard to chemical equivalents, with a vote of four in each list.

Textbook Assignment.—Answers to the last question (which topics can be treated adequately by textbook assignment and recitation?) are relatively few in number. There is, however, considerable agreement that chemical theories, industrial processes, commercial applications and practical uses, and the general laws of chemistry (including the periodic law) may well be taught in this way. Only two teachers mention the history of chemistry under this heading. One teacher is willing to teach any topic from the textbook. Eight state emphatically that in their opinion no topic should be assigned without experimental illustration unless it is based upon some previous experience on the part of the pupil.

Results of Investigation.—As previously stated, the results of this questionnaire have such significance as may lie in the mature opinion of a considerable number of experienced high-school teachers of chemistry. We ask whether laboratory instruction is worthwhile; whether it yields returns commensurate with the high cost of modern equipment and the large expenditure of time and effort which thorough laboratory courses entail.

A majority, but not a large majority of the replies, are in the affirmative. It appears that the question should receive further study by the experimental method. A tentative program would be as follows. A series of lessons might be planned, covering a limited but typical list of topics; descriptive, quantitative, theoretical. Alternative development plans, framed by competent teachers, would be provided for each topic according to the laboratory or recitation method. Coöperating teachers would be asked to use one plan with one or more divisions, and the alternative plan with other divisions. Achievement would be measured by uniform objective tests given when each topic was completed and retention measured by similar tests given after an interval of several weeks. If the coöperation of a sufficient number of schools could be secured, the results should

lead to a definite conclusion. I recommend that this matter be considered by the executive committee of the Division.

In conclusion, the writer extends sincere thanks to all teachers who have answered the questionnaire, and especially to the members of his committee who assisted so materially in formulating it. For interpretation of the replies and for any expressions of personal opinion in this paper, the chairman of the committee is alone responsible.

FRANK M. GREENLAW, *Chairman*

THE PROFESSOR'S DECALOG

1. Thou shalt love no college except This Particular One.
2. Thou shalt have no worldly interests outside the College; neither shalt thou serve them, nor make any money therefrom. For the College is a jealous College, and does not approve any division of interest.
3. Thou shalt not know many of the Trustees; for the College will not hold him guiltless who cultivates the Trustees—in vain.
4. Remember the Sabbath Day, not to play golf therein. Six days shalt thou labor and do all thy work; but on the seventh day shalt thou be with thy family, and in it thou shalt beat the rugs, wash the windows, clean the car, and also grade student papers and prepare lectures for the coming week.
5. Thou shalt approve of everything, both in the Faculty and Student Body. This the fifth and great commandment.
6. Thou shalt not grumble nor cuss at anything whatsoever.
7. Thou shalt not dress too well, nor drive an expensive car.
8. Thou nor thy wife nor thy children shall not tell tales in any public place against thy neighbor or any student.
9. Thou shalt not covet thy neighbor's salary, nor his house, nor his dog, nor his Clubs, nor any pull that he has.
10. Honor the College and all its ways, that thy days may be long upon the Campus which thy College hath given thee to walk and work on, loving and serving all the students with all thy soul and with all thy mind and with all thy strength. And in the end a few of them will remember thee and richly reward thy service to the College with their friendship and esteem.—*Tufts Weekly*

Liebig and Wöhler Anniversaries. A joint celebration was recently held at Darmstadt to celebrate the one hundred and twenty-fifth birthday of Justus von Liebig on May 12, 1928, and the centenary of the synthesis of urea by Wöhler. Besides representatives of the German chemical societies, others from European countries and from Japan were present. The memorial address on Liebig was delivered by Haber, of Berlin; Professor Wohl, of Danzig, spoke on Wöhler. Wöhler's original preparations of urea and of aluminum had been borrowed from Göttingen for the celebration. The birthplace of Liebig, which had to be razed in 1920 because of its dilapidated condition, has been exactly reproduced, as a result of contributions from German chemists and chemical manufacturers, and is now to serve as a museum in commemoration of Liebig and of the industries which originated with him. There is a Liebig museum at Giessen as well as at Darmstadt.—*Science*, **68**, 271 (Sept. 21, 1928).

The Chemistry Student

HOW TO STUDY CHEMISTRY

Let us say at the outset that we have discovered no royal road to learning. There is no method of study which obviates the necessity for hard work on the part of the student. Yet study can be made easier in the sense that a certain amount of effort rightly directed will accomplish far more than the same amount mistakenly, though earnestly, applied.

Professor George Fillmore Swain has written an excellent little pamphlet on "How to Study"[1] which we heartily recommend to all students. The present article is based largely upon portions of Professor Swain's booklet, with some interpolations and comments intended to apply more particularly to chemistry.

The Proper Mental Attitude

Professor Swain begins by counseling the student to adopt the proper mental attitude. To this end it is necessary that the student distinguish between mere reading or even memorizing, and understanding.

> No doubt every one finds himself at times reading merely words or phrases without understanding them, reflecting about them, or translating them into terms which are intelligible to his understanding. Such reading is worse than useless; it leads to actual mental injury. Whenever we find ourselves doing this we should therefore arouse ourselves, make an effort of the will, and concentrate our attention upon the subject, insisting upon understanding it. If for any reason we are unable to do this, we should close the book, take some exercise or recreation, or at any rate do something else, for we are not at the moment fitted for study. We might as well eat sawdust and deceive ourselves with thinking that we are taking nourishment. It is not what is read or what is remembered, but only what is understood, that gives power.

Furthermore, he must learn to distinguish mere facts from conclusions or opinions.

> Mere facts, some of which may be the result of laborious investigation, may be accepted without verification, if the authority is good. . .
>
> Very different are conclusions or opinions deduced from facts; and logical conclusions are very different from mere opinions. The facts may be sufficient to prove logically a certain conclusion. On the other hand, the facts may simply give reasonable ground, or appear to give reasonable ground, for a certain opinion, though they may fall far short of demonstration. The student must, therefore, discriminate constantly between mere statement of facts, necessary conclusions which follow therefrom, and mere opinions which they seem to render reasonable.

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[1] McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City. $0.25, net.

Most important of all, the student should maintain a questioning attitude of mind.

> He should always ask himself, regarding any statement which he reads, whether there is a reason for it, and if there is, whether it is inherent in the nature of things, so that he might independently arrive at it, or whether it follows from facts which the writer has observed.

He should ask himself whether there is any connection between a new fact or idea which he encounters and others which he has previously learned and if so what that connection is. When he encounters a statement he should consider not only the statement itself but its implications. Thus the facts that mercury has a density of 13.55 and iron a density of 7.85 imply that iron will float on mercury. The atomic theory of the nature of matter implies the laws of definite and multiple proportions. (How?)

When the student encounters a law he should ask himself whether that law has been stated as generally as possible or whether it is a special case of a broader and more general law. (Compare Richter's law with the law of chemical equivalents.) Methods of preparing compounds should be scrutinized with a view to determining whether they are unique or general. If the method employed in a certain case is not general, what are the general methods for that type of preparation? Could one of them be employed? If not, why not? If so, what are the advantages of the special method?

Studying Understandingly

Professor Swain emphasizes the fact that to study understandingly the student must cultivate the habit of forming definite ideas. It does him no good to read that "matter is discrete rather than continuous" if he gets no clear idea of what is meant. The student should resort to the dictionary as frequently as necessary to make sure that he knows the exact meanings of the words which he encounters. He should learn to distinguish between words of definite meaning and words which are vague or ambiguous. Also he should learn to recognize words which have definite meanings but which are often wrongly or loosely applied. Thus, a "strong" acid is not synonymous with a "concentrated" acid, nor a "weak" base with a "dilute" base. Furthermore, he should learn to recognize words which express single ideas, and words which can be analyzed into simpler components. Thus "momentum" involves "mass," "time" and "distance," for momentum is the name given to the mathematical product of mass $\times$ velocity, and velocity is distance traveled in unit time. Finally, he must realize that naming a thing, phenomenon, or condition is not always equivalent to explaining it. To say that certain changes in a system come about by reason of "alterations in the thermodynamic environment" explains nothing.

The practice of studying good definitions and determining the necessity for every term included is a great aid toward forming definite ideas. It is even more helpful, if you have access to a textbook which does not insist upon confronting you with definitions at every turn, to study the discussion until you understand it thoroughly and then frame your own definition. Test it by trying to think of exceptions. When, finally, you have made it as nearly perfect as possible, turn to some standard authority and compare his definition with your own. Are they essentially the same? Has he included some qualification or limitation which you have omitted?

The habit of memorizing definitions for reproduction upon demand, without thoroughly understanding the thing or idea defined, is slow mental suicide. If you thoroughly understand the matter you study you need never memorize a definition, for you will always be able to frame your own.

The student should also learn to state things in different ways and from different points of view. This involves a recommendation which we have already made—to consider the implications of a statement. Professor Swain quotes an amusing anecdote related by Wm. James in his "Talks to Teachers."

> A friend of mine visiting a school was asked to examine a young class in geography. Glancing at the book, she said: "Suppose you should dig a hole in the ground, hundreds of feet deep, how should you find it at the bottom—warmer or colder than on top?" None of the class replying, the teacher said: "I'm sure they know, but I think you don't ask the question quite rightly. Let me try." So, taking the book, she asked: "In what condition is the interior of the globe?" and received the immediate answer from half the class at once: "The interior of the globe is in a condition of igneous fusion?"

Ridiculous as this incident may seem, it has its parallels daily in high-school and college chemistry classes.

In learning to state facts in different ways the student should remember that "mathematics is a language," and one with which the man of scientific occupation or interests must become thoroughly familiar. Not all principles are capable of mathematical expression, but those which are may be stated mathematically with elegance and precision. Learn to translate equations into words and vice versa.

It is also well to express ideas negatively or in reverse and to see how far the reverse statement holds true. Thus, all chemical compounds are homogeneous substances. Is it correct to say that all homogeneous substances are chemical compounds?

Classify and Correlate

Try to classify and correlate what you learn. Especially try to note how the facts which you encounter can be explained by the general theories you have learned. Professor Deming gives an excellent example in his

"General Chemistry,"[2] when he compares the properties of gases with the molecular theory.

HOW THE MOLECULAR THEORY EXPLAINS THE PROPERTIES OF GASES

Observed Facts	*Explanation*
Gas pressure.	Bombardment of walls by molecules.
Diffusibility.	Molecules in rapid motion.
Compressibility.	Large spaces between molecules.
Liquefaction. Gases condense to form liquids when compressed and cooled.	Molecules tend to cohere when closely packed, especially at low temperatures.
Increase of pressure or volume with increase of temperature (Charles' Law).	Molecules move more rapidly at higher temperatures.
Decrease of volume with increasing pressure (Boyle's Law).	Increased pressure confines molecules in proportionately smaller volume.
Gases are cooled but slightly by expanding into a vacuum (Joule's Law).	Molecules of a gas have but slight attraction for each other, or tendency to cling together. If such attraction did exist energy would be absorbed in overcoming it.
Deviations from Laws of Charles and Boyle.	Attraction or cohesion between molecules not altogether absent. Volume occupied by molecules not altogether negligible.
Each gas, in a mixture of gases, exerts the same pressure that it would if it occupied the whole space alone (Dalton's Law of Partial Pressures).	Molecules are so far apart that they move without interference from each other; and when they happen to collide, rebound without loss of energy.
The preceding facts viewed in relation to the laws of energy.	A given volume, under given conditions, contains nearly the same number of molecules for all gases (Avogadro's Principle).

A Point to Remember

The student should keep in mind that an elementary study of a subject is not a superficial study. It is first necessary to lay a foundation and erect a skeleton before a finished structure can be attempted. Try to get at the fundamentals of any subject which you study.

We have exhausted neither the subject nor Professor Swain's recommendations, but perhaps we have offered enough for one sitting. At the risk of being accused of plugging for the publishers we urge all students to obtain a copy of "How to Study" and to spend about two hours in reading and digesting it. Thereafter an occasional glance at the outline in

[2] "General Chemistry," Horace G. Deming, John Wiley & Sons, Inc. Second edition, 1925, p. 27.

the front of the booklet should serve as a reminder to maintain proper habits of study.

Test Your Own Habits of Study

Perhaps you have already learned to study properly. If so, you should find no difficulty in answering the following questions.

1. Here is a little exercise in logic. "To call you an animal would be to state the truth." "To call you an ass would be to call you an animal." "To call you an ass would be to state the truth." Where is the fallacy, if any?

2. Which is the better definition—"Matter is that which can occupy space" or "Matter is that which occupies space?"

3. The space between the jacket and the flask of a thermos bottle contains a vacuum. Hence we may say that the vacuum occupies that space. Is it therefore correct to say that a vacuum is a form of matter? Why, or why not? (What is a vacuum?)

4. "All samples of a given compound contain the same elements, in the same proportion by weight." Does it necessarily follow that all samples which contain the same elements in the same proportion by weight are samples of the same compound? If not, can you cite exceptions? (Ask an organic chemist.)

Cheating in Exams Put to Use by Psychologist. The parasite student, who slips through college by cribbing information from more industrious or more brilliant students, has at last been made useful. Unknown to themselves, 30 successful cheaters at Colgate University were studied by Herbert C. Brownell and used as laboratory specimens showing the mental and emotional traits of college men who cheat at examinations—and get away with it.

Information about the 30 was obtained by underground and unofficial channels, Mr. Brownell states in reporting his investigation to *School and Society*. None of these cheaters were officially caught even by a severe proctoring system.

Eighty per cent of the group were more psychoneurotic, or emotionally unstable, than the campus average. More than half fell below the campus average in intelligence, and the majority belonged to the psychological type known as extroverts, that is, good social mixers and more inclined to activity than to thinking.

"Contrasted with the student body, the cribber becomes a psychological type," Mr. Brownell concludes. "His low intelligence may make cheating somewhat of a necessity. His extroversion may operate to further this. His emotional instability may make it easier for the spirit to succumb under the two-fold necessity."

More than half the college cheating could be eliminated if this psychological type were eliminated. With the general type would go most of the "all round" college men who shine in team and track contests, glee clubs, dramatic productions, and other bookless activities.—*Science Service*

THE STRUCTURE OF MATTER. II. THE PERIODIC CLASSIFICATION OF THE ELEMENTS

OTTO REINMUTH, ASSOCIATE EDITOR

It is one of the most characteristic traits of the scientist that he attempts to discover relationships between facts and things and then to arrive at the reasons for those relationships.

Chemists early discovered that certain groups of elements had similar properties. Before 1839 Döbereiner had called attention to a number of triplets or "triads" of elements. He further pointed out that the elements composing any one triad either had almost the same atomic weights or that their atomic weights differed by an almost constant amount. This was a beginning, but Döbereiner was never able to make all the known elements fit into his system or to discover any logical basis for it.

Numerous other investigators tried their hands at the problem. By 1865 J. A. R. Newlands was getting hot on the trail. He found that when he listed the elements in the order of increasing atomic weights, every eighth element usually had properties similar to the first. The importance of Newlands' discovery was not fully appreciated at the time as the following incident related by Professor Mellor[1] will indicate.

> When Mr. Newlands read a paper on "The Law of Octaves" at a meeting of the London Chemical Society in 1866, Prof. G. C. Foster said that any arrangement of the elements would present occasional coincidences, and inquired if Mr. Newlands had ever examined the elements according to their initial letters. Twenty-one years later the Royal Society awarded Newlands the Davy Medal for his discovery.

Newlands' arrangement, however, took account only of the elements known at that time, and the fact that certain elements were missing from the list somewhat marred the beauty of his classification. Both Meyer and Mendeléeff realized the possibility of undiscovered elements and they did not hesitate to leave gaps in their tables when it was necessary to do so to make elements of similar properties fall in the same columns. Mendeléeff even went so far as to predict the properties which several of these elements would display when discovered. His predictions were based upon analogy and they did not pretend to be more than rough approximations, but they received striking confirmation when scandium, gallium, and germanium were discovered. In the case of germanium (which Mendeléeff had called "ekasilicon") the agreement between the predicted and observed properties was little short of marvelous, as the following comparison from Moore's History of Chemistry[2] will show.

[1] "Modern Inorganic Chemistry," J. W. Mellor, Longmans, Green and Co., New York, **1925,** p. 991.

[2] "A History of Chemistry," F. J. Moore, McGraw-Hill Book Co., Inc., New York, **1918,** p. 188.

D. MENDELÉEFF

	Properties predicted for "ekasilicon"	Properties observed in germanium
Atomic weight	72.0	72.3
Specific gravity	5.5	5.469
Atomic volume	13.0	13.2
Specific gravity of oxide	4.7	4.703
Boiling point of chloride	100°	86°
Specific gravity of chloride	1.9	1.887
Boiling point of ethyl compound	160°	160°
Specific gravity of ethyl compound	0.96	1.0

It would be wrong to say that these confirmations furnished definite proof of Mendeléeff's law, but they did constitute strong evidence in support of it, and the dramatic element in the situation arrested every one's attention. In science, as elsewhere, the gift of prophecy is highly impressive.

Mendeléeff had stated his law by saying, "When I arranged the elements according to the magnitude of their atomic weights, beginning with the smallest, it became evident that there exists a kind of periodicity in their properties. . . I designate by the name 'periodic law' the mutual relations between the properties of the elements and their atomic weights; these relations are applicable to all the elements, and have the nature of a periodic function." In more concise terms we may say, *the properties of the elements are a periodic function of their atomic weights.*[3]

The Reasons Behind the Law

The periodic law and the tables based upon it constituted a brilliant advance in the direction of introducing system into chemistry. They did not at first, however, contribute anything to the theory of the science. Just why does this "periodicity of properties" exist? How is it connected with the atomic weights? These were at first very puzzling questions. Furthermore, there were some exceptions to Mendeléeff's law, even after he had made due allowance for the elements which he believed were yet to be discovered. In a few cases he had to reverse a pair of elements in order to make them fall into columns with other elements which they resembled. At first it was thought that these exceptions were due to mistakes in determining atomic weights, but as methods of analysis were refined and as atomic weights were determined more and more accurately, this explana-

[3] The terms here employed are more familiar to mathematicians than to the general reader. When we say that one value is a *function* of another we mean that as the second value changes the first changes also, and we imply that one change somehow depends upon the other. A *periodic function* repeats its value at regular intervals or "periods." Translated into simpler phraseology the periodic law states that the properties of elements are somehow dependent upon, or at least connected with, their atomic weights. Also that, taking the elements in the order of their atomic weights, we find a repetition of similar properties at regular intervals.

tion had to be abandoned. It appeared, then, that Mendeléeff was not precisely correct. The properties of all elements did *not* depend upon their atomic weights. But it was equally obvious that he was very "warm." Something closely associated with the atomic weights must be the determining factor. What was the answer?

TABLE I

Known Facts				Theoretical Postulates[4]			
Element	Symbol	Atomic wt.	Chief valences	Protons	Nuclear electrons	Atomic no.	Valence electrons
Hydrogen	H	1.008	1+	1	0	1	1
Helium	He	4.000	0	4	2	2	2
Lithium	Li	6.940	1+	6	3	3	1
				7	4		
Beryllium	Be	9.020	2+	9	5	4	2
Boron	B	10.82	3+, 5−	10	5	5	3
				11	6		
Carbon	C	12.00	4	12	6	6	4
Nitrogen	N	14.008	5+, 3−	14	7	7	5
Oxygen	O	**16.000**	2−	16	8	8	6
Fluorine	F	19.00	1−	19	10	9	7
Neon	Ne	20.20	0	20	10	10	8
				22	12		
Sodium	Na	22.997	1+	23	12	11	1
Magnesium	Mg	24.320	2+	24	12	12	2
				25	13		
				26	14		
Aluminum	Al	26.97	3+	27	14	13	3
Silicon	Si	28.06	4	28	14	14	4
				29	15		
				30	16		
Phosphorus	P	31.027	5+, 3−	31	16	15	5
Sulfur	S	32.054	6+, 2−	32	16	16	6
Chlorine	Cl	35.457	7+, 1−	35	18	17	7
				37	20		
Argon	A	39.91	0	36	18	18	8
				40	22		
Potassium	K	39.10	1+	39	20	19	1
				41	22		
Calcium	Ca	40.07	2+	40	20	20	2
				44	24		
Scandium	Sc	45.10	3+	45	24	21	3
Titanium	Ti	48.10	4	48	26	22	4
Vanadium	V	50.96	5+, 3−	51	28	23	5
Chromium	Cr	52.01	6+, 2−	52	28	24	6
Manganese	Mn	54.94	7+, 1−	55	30	25	7

[4] Although these data are listed as "theoretical postulates," they may now be said to have been thoroughly substantiated by circumstantial experimental evidence.

Let us temporarily retrace our steps a little. Man has always held the belief that the laws and processes of nature are fundamentally simple—that if we can only strip away the details which confuse us and cut to the heart of a matter, the intricate will be made plain. This is what is known as a "gratuitous assumption"—something which we cannot prove and which may be untrue, but which we usually take for granted. Long before chemistry had become a science, philosophers had toyed with the idea that all matter might be reduced to a single essence—that all the forms of material which we know might be only different structures built up out of some primary building matter. Years before Mendeléeff stated his law Proust had suggested that all the elements might be built out of the simplest element, hydrogen. He believed that if the atomic weight of hydrogen were taken as one, all the other elements should have whole numbers for atomic weights. This hypothesis had to be scrapped eventually for the same reason that the explanation of Mendeléeff's exceptions had to be rejected. Modern developments have shown, however, that Proust, fumbling in the dark, had almost laid his hands upon the truth.

Even during Mendeléeff's lifetime (he died in 1907) much was discovered concerning the structure of matter and sufficient evidence was accumulated to make it seem certain that there are two different kinds of building stones out of which atoms are constructed—protons and electrons. These we have already discussed briefly in the first article of this series.[5] How could these building stones be put together to form elements which would have the properties which we have found existing elements to display?

It was a difficult question and there were almost no rules to go by. The theorists were not dismayed however. They went to work and made their own rules as they went along, the only limitations being that the rules be consistent with known facts and that they work out to give the right answer. Finally, the idea of the structure of the atom which we have already described[5] began to emerge. We have as yet studied only a few of the elements, but let us resort to the reference books to accumulate a few facts about the first twenty-five of them, and let us then see what the theorists did and how their ideas fitted in with the periodic classification. The few facts which we shall need to go on are tabulated in Table I.

At this point it may be well to consider a definition or two. We have already defined the *nucleus* and the *kernel* of the atom.[5] Here let us introduce a new term—the *atomic number*. This we shall understand to mean the number of electrons outside the nucleus. We shall also have cause to make use of *valence*. We have already explained chemical combination on the basis of the exchange or sharing of electrons.[5] In the case of polar combination we shall say that the number of electrons lost or gained by an

[5] "The Structure of Matter. I. Hydrogen and Oxygen," THIS JOURNAL, **5**, 1152–63 (September, 1928).

atom in combining with another atom or atoms, constitutes its *valence*. If one atom loses two electrons to another atom in forming a compound with it, it is customary to say that the first atom has a *positive* valence of two in that compound. The second atom has a *negative* valence of two. The respective valences of the two atoms are therefore 2+ and 2−. In cases of non-polar or partially polar combination we shall say that the number of electron *pairs* shared with other atoms constitutes the valence number. Later we may have reason to amplify our discussion of valence somewhat, but the foregoing will do for the present.

Isotopes and the Packing Effect

Upon examining Table I, one immediately notices that in the column headed "Nuclear Electrons," several elements are followed by more than one figure. If "every atom of an element is precisely like every other atom of that element," as Dalton said it was, how can these figures be correct? The answer is that Dalton was wrong. Some elements are mixtures of atoms which are not quite the same. The differences in these atoms occur in the nuclei only, however; outside the nuclei they are exactly the same. When an element is made up of two or more kinds of atoms, these different kinds of atoms are called *isotopes*. Isotopes differ from each other only in weight; in chemical properties they are identical. It is evident, therefore, that the atomic weight of an *isotopic* element is an average, just as the "molecular weight" of air is an average. This is one reason why the atomic weights of the elements are not all whole numbers.

But we notice that helium has four times as many protons and four times as many electrons as hydrogen. Why is not the atomic weight of helium exactly four times that of hydrogen? Why is not the atomic weight of oxygen exactly sixteen times that of hydrogen? None of these elements are isotopic. Without going into an obscure and involved mathematical discussion we may say that this anomaly is known as the "packing effect." It is explained upon the basis of the newer theories of physics. Classical physics (the kind we studied in school) treated matter and energy as two entirely separate things. Furthermore, it considered mass (measured as weight) as an unchanging property of matter, and it taught that neither matter nor energy can be destroyed. The newer physics holds that matter and energy are much more closely related than we had formerly thought—that they may, in fact, be converted, the one into the other. Mass is now considered to be a property, not of matter alone, but of matter and energy. Therefore, when four protons and four electrons are combined to form an atom of helium, they constitute a system which has an entirely different energy content than a system composed of four hydrogen atoms. On the basis of the newer physical theories an

H. G. J. MOSELEY
1887–1915

atom of helium *should not* weigh precisely as much as four atoms of hydrogen.

Restating the Periodic Law

Turning again to the table we note that all the elements except two are listed in the order of their atomic weights. These two, argon and potassium, have been interchanged. But if we note the atomic numbers (the numbers of electrons outside the nuclei) we find that they fall in order. It appears then that the properties of the elements are a periodic function, not of their atomic weights, but of their *atomic numbers*.

The brilliant young British physicist, Moseley, who was later killed at Gallipoli in the World War, found that it is possible to determine the atomic numbers of elements by means of x-ray spectra. Most of the elements here listed have been investigated and the atomic numbers assigned to them have been experimentally verified.

Constructing a Periodic Table

There is a legend to the effect that Mendeléeff first began to classify the elements in order to make chemistry clearer to his students. It is said that he used to note on cards the principal facts concerning each element and then pin the cards to the wall so that like elements were grouped together. Let us adopt a somewhat similar scheme. On each card we shall note the symbol of the element, its atomic number, its atomic weight, and a diagram of its atom. This diagram is not to be considered a picture or even a plan of the atom but only a graphical reminder of its "specifications." The small circle at the center will represent the nucleus and the figures within the circle will state the number of protons and electrons which it contains. The broken circles surrounding the nucleus will represent layers or shells of electrons and the extra-nuclear electrons themselves will be designated by large black dots.

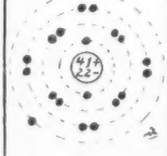
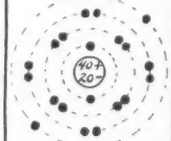
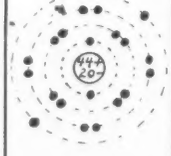
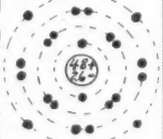
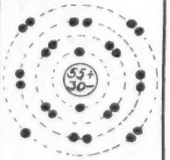
Let us lay aside for a moment the first two cards and take up the other twenty-three. That on top is lithium, with an atomic number of 3, a valence of 1+, and one valence electron. Let us place this card near the upper left-hand corner of the desk. Number 4 is beryllium with two valence electrons and a valence of 2+. Let us place it immediately to the right of number 3. Number 5 is boron with valences of 3+ and 5− and with three valence electrons. Let us place this to right of number 4. Number 6 is carbon, with four valence electrons and a valence of 4. It goes to the right of number 5. Number 7 is nitrogen with valences of 5+ and 3− and with five valence electrons. We shall place it to the right of carbon. Number 8 is oxygen with a valence of 2− and with six valence electrons. It, in turn, goes to the right of number 7. Number 9 is fluorine with seven valence electrons and a valence of 1−. We shall

place it to the right of oxygen. Number 10 is neon with a stable valence shell of eight electrons; consequently, it does not enter into chemical combination and has no valence at all. Let us place it at the extreme right of our horizontal row. With number 11 we find that we are beginning a new period. Sodium, like lithium, has one valence electron and a valence of 1+. Let us place number 11 directly below number 3. Number 12 is magnesium which, like beryllium, has two valence electrons and a valence of 2+. Let us put number 12 to the right of number 11 and immediately below number 4. Proceeding in this fashion we find that number 13, (aluminum) falls below number 5 (boron); that silicon (number 14) falls below carbon (number 6); phosphorus below nitrogen; chlorine below fluorine; and argon below neon. With number 19, potassium, we again begin a new period. Potassium, with one valence electron and a valence of 1+ is placed beneath sodium and lithium; calcium, below magnesium and beryllium; scandium under aluminum and boron; titanium under silicon and carbon; vanadium under phosphorus and nitrogen; chromium under sulfur and oxygen; and manganese under chlorine and fluorine.

We have now distributed all of our cards except the first two. Number 1 is hydrogen with one valence electron and a valence of 1+. The logical place for this card seems to be directly above lithium. Number 2 is helium, with two valence electrons but with no valence. It will be recalled that in the first article of this series[5] we stated that two electrons constituted the stable number for the first electron layer or shell outside the nucleus. Helium has this stable configuration and hence does not enter into chemical combination. It, therefore, seems appropriate to place number 2 at the top of the eighth vertical column of cards just above number 10.

We now have a layout which looks like the chart reproduced on the folder facing this page, and we begin to see why the periodicity which Mendeléeff noted should exist. Elements of similar chemical properties fall in vertical columns. With the exception of helium, which we have just discussed, all the elements in any one vertical column have the same number of valence electrons. Each element differs by 8 in atomic number from the element immediately above or below it.

So far our "Periodic Table" is a marvel of system and order. But there is a fly in the ointment. According to the arrangement which we have been following we should expect to find that element number 26 has a stable valence shell of eight and does not enter into chemical combination. What a rude shock to find, on referring to the reference books, that number 26 is iron, with valences of 2+ and 3+. It is time to make some new rules. Can we make them, and proceed without scrapping what we have already done? Yes. A later article in this series will tell how the theorists dealt with this difficulty.

H 1 1.008							2 He 4
Li 3 6.940	Be 4 9.02	B 5 10.82	C 6 12	N 7 14.008	O 8 16	F 9 19	Ne 10 20.2
Na 11 22.997	Mg 12 24.32	Al 13 26.97	Si 14 28.06	P 15 31.027	S 16 32.064	Cl 17 35.457	A 18 39.91
K 19  39.096	Ca 20   40.07	Sc 21 45.1	Ti 22  48.1	V 23 50.96	Cr 24 52.01	Mn 25  54.93	

CARBON DIOXIDE IN MODERN LIFE*

"Of all the different gases met with in nature," says Mr. Donald, "there is none more closely identified with our daily life than carbon dioxide. It occurs in the atmosphere to the extent of 4/10,000ths of 1% and vegetable growth is dependent to a large extent on its assimilation from the atmosphere. Whenever carbonaceous material is burned, for example, coal or wood, it is given off in large quantities. When sugar ferments to alcohol, it is formed at the same time in almost equal quantities. Quantities of this gas are also liberated in the manufacture of cement, the burning of lime and in other of our industrial processes."

Carbon dioxide was first known as "fixed air," to distinguish it from ordinary air, and its properties were studied by Bergmann, Priestley, and Lavoisier. The latter first showed that carbon dioxide is a compound of carbon and oxygen.

"Attention was first attracted to carbon dioxide in a curious way. In the seventeenth century a great deal of faith was placed in the medicinal and curative powers of the various springs located in Europe. People from different points journeyed to these springs to take the cure. Many of these, being unable to remain indefinitely at the springs, carried water away with them to complete their treatment. Attempts were also made to duplicate the curative powers of the natural waters by manufacturing artificial waters from various salts. It was found, however, that these manufactured waters were flat and insipid, and this brought investigation of the gas bubbling forth at the springs and charging the water."

Early Production Processes

"As soon as the properties of the gas became known, its manufacture from carbonate of soda and sulfuric acid, or limestone and sulfuric acid, was undertaken. In this way came about the use of carbon dioxide in mineral waters, and the origin and development of the extensive mineral water business which is still the largest individual consumer of carbon dioxide gas."

Early processes for manufacturing carbon dioxide were based upon two reactions: (1) the action of sulfuric acid on carbonates, for example:

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O,$$

and (2) the decomposition of carbonates by heat, *e. g.*,

$$MgCO_3 + \Delta \longrightarrow MgO + CO_2.$$

Later the coke process was developed. In this process the gas is obtained by burning coke. It is washed with water and absorbed in cold potassium carbonate solution according to the following reaction:

* Digest of an article by J. R. Donald in *Canadian Chemistry & Metallurgy*, **12**, 3–7 (Jan., 1928).

$$K_2CO_3 + CO_2 + H_2O \longrightarrow 2KHCO_3$$

This reaction is reversed by the application of heat and the CO_2 is collected and led into a gas holder for subsequent compression.

History repeats itself in that we are now turning to a source of carbon dioxide which was noted and employed by the versatile Priestley.

"About three or four years ago, a new process was developed which bids fair to replace a very considerable portion of the carbon dioxide produced by the coke process. There is available in the alcoholic fermentation industry large quantities of by-product carbon dioxide of a high degree of purity but contaminated with foreign odors. A small quantity of this fermentation gas has been recovered and used in the brewing industry, but for soft drinks, refrigeration, and many other industrial uses, a gas smelling strongly of the products of fermentation is undesirable. Removal of these odors from the gas has been a fairly difficult problem."

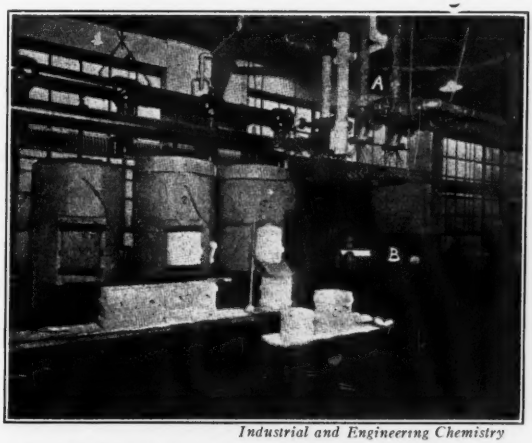
The Backhaus Purification Process

"Some five years ago the Research Department of the U. S. Industrial Alcohol Company at Baltimore decided to investigate this purification problem. As a result, there was developed by Dr. Backhaus a purification process which is usually called the Backhaus Process. This process is based on the selective power of adsorption which is characteristic of activated carbon. In practice, the gas is passed through absorption towers, packed with activated carbon. The carbon first becomes saturated with carbon dioxide, which very quickly occurs, and thereafter the carbon dioxide passes through the absorption mass. The impurities in the carbon dioxide which are there as a very small percentage of the gas are however retained by the activated carbon until the carbon in turn becomes saturated with these impurities. When this takes place the absorbers are cut out, and live steam is blown through the carbon mass and the impurities steamed out."

Uses of Carbon Dioxide

"By far the largest market for carbon dioxide exists in the beverage industry. Its use in this field is dependent on a number of important functions. In the first place it imparts life to the drink, improving the appearance and giving it the well-known sparkle. It also has a marked stimulating effect on the senses of taste and smell and brings out the flavors in the drink. Furthermore, it possesses a valuable preservative action and inhibits the growth of bacteria. A well-carbonated, bottled water rapidly becomes almost sterile on standing, and even where the bacterial count of a bottled drink is originally unduly high the action of the carbon dioxide for a period of a few days rapidly reduces this count."

"Carbon dioxide has also found a considerable outlet in other food products. Wherever the presence of air is detrimental to the keeping qualities of the product carbon dioxide may be considered as a possible substitute for the contained air. For example, in the case of shredded cocoanut, great difficulty was found in keeping it sweet when packed in containers. The difficulty was overcome by packing the shredded cocoanut in an atmosphere of carbon dioxide. In a similar way this gas has been used in the packing of tobacco, coffee, and a number of other products. It has also found a use in the manufacture of butter and ice cream. In the manufacture of both these commodities considerable quantities of air



Industrial and Engineering Chemistry

PLANT MANUFACTURING SOLID CARBON DIOXIDE. THREE EVAPORATORS IN THE FOREGROUND, WITH MOLDS AND FINISHED BLOCK

(*A*) Heat interchangers for cooling liquid CO_2
(*B*) Hydraulic blocking press

are beaten into the product during the churning process. The claim has been made that by substituting an atmosphere of carbon dioxide for one of air the keeping qualities of both the butter and ice cream are improved."

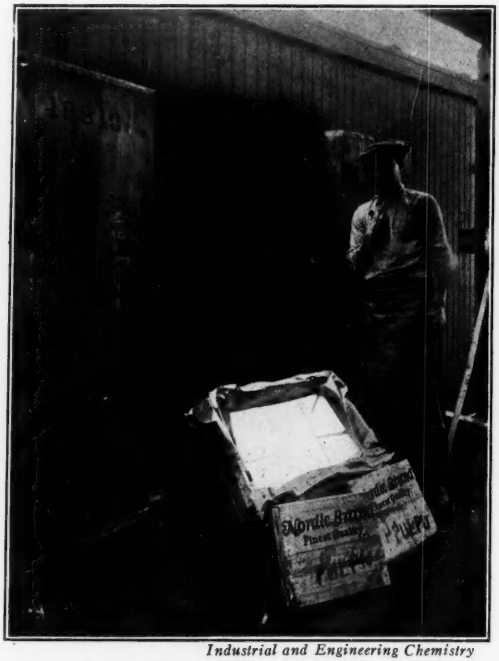
Carbon dioxide has been successfully employed as a refrigerant gas in the same manner that ammonia and sulfur dioxide are used. It has now entered the refrigerant field in a new guise.

"Solid carbon dioxide, known by the name of 'Dry Ice,' is manufactured from the gas by compression, liquefaction, and expansion. The snow thus formed is packed and compressed into blocks, producing cakes of ice. The temperature of this 'Dry Ice' is —176°F. (—80°C.). Its advantages as a refrigerant are based on the following facts:

"1. It produces a dry gas without the formation of any liquid.

"2. 1 lb. of this ice will absorb approximately twice as much heat as 1 lb. of water ice, figuring both refrigerants at 0°C.

"3. In the ordinary household refrigerator, the carbon dioxide also has the further advantage that it is constantly replacing the gaseous content of the refrigerator with fresh, pure, dry carbon dioxide gas which, if anything, has a slight beneficial preservative action.



Industrial and Engineering Chemistry

SOLID CARBON DIOXIDE IN ORDINARY WOODEN PACKING CASES IS DISTRIBUTED THROUGHOUT A CARLOAD OF FISH TO KEEP IT FROZEN IN TRANSIT

"4. Where low temperatures are required, these may be obtained by the direct use of carbon dioxide ice, whereas temperatures below about 40°F. require the use of salt with ordinary ice, and it is not possible to obtain temperatures much below the freezing point of water."

Theoretically, pure carbon dioxide should be the ideal fire extinguisher. Some of the practical difficulties which stood in the way of this application have been overcome recently.

"Ordinary combustion is inhibited if the atmosphere is charged with 15%

of carbon dioxide, and the combustion of even the most inflammable liquids and gums is completely inhibited at 20% of carbon dioxide. In addition to the action of the carbon dioxide in reducing the oxygen content of the atmosphere, there is the added function of the cooling effect of the gas as it is released from its liquid condition. Its use is obviously limited to confined areas or concentrated fires where the carbon dioxide dilution can be maintained.

"While these theoretical considerations have been known for some years, the use of carbon dioxide for fire extinction remained dormant until it received a sudden impulse from the idea of a Swedish engineer, who modified the carbon dioxide cylinder in such a way that rapid discharge of its content could be obtained. The ordinary carbon dioxide cylinder is analogous to a steam boiler under pressure. In the lower two-thirds of the cylinder liquid carbon dioxide exists; in the upper one-third the gas exists under approximately 1000 lb. pressure in the same way that steam exists above water in a boiler. When the valve on the cylinder is opened

Fyre-Freez Corp.

EXTINGUISHING AUTOMOBILE TRUCK FIRE WITH CARBON DIOXIDE SNOW

(News Edition, *Ind. & Eng. Chem.*, **6**, 12, Sept. 10, 1928.)

Fyre-Freez Corp.

EXTINGUISHING GASOLINE FIRE WITH CARBON DIOXIDE SNOW

(News Edition, *Ind. & Eng. Chem.*, **6**, 12, Sept. 10, 1928.)

the gas escapes and the liquid boils, but the rapid release of the gas from the liquid state gives a pronounced cooling effect, resulting in the formation of solid carbon dioxide, which plugs the valve. The discharge is then slowed down, until heat is absorbed, when another rush of gas takes place followed by another freezing-up of the valve. For this reason the discharge of a 50-lb. cylinder of carbon dioxide takes a very considerable period. As an alternative, this Swedish engineer conceived the idea of carrying a tube from his valve to the bottom of his cylinder. As a result, when the valve is opened, liquid carbon dioxide is discharged from the valve in the same way as water is blown off from a boiler. A 50-lb. cylinder of carbon dioxide with a siphon valve can be discharged in about 40 seconds, whereas an ordinary cylinder will take a period of some hours. With a number of the new type of cylinders connected to a header, the necessary volume of carbon dioxide required to render combustion impossible in any given cubical content can be released in a few seconds."

Many other uses for carbon dioxide are being discovered. For instance, medical men have found that a concentration of the gas slightly above that normally present in the atmosphere stimulates the respiratory organs to greater effort. Hence, a small quantity of carbon dioxide added to the oxygen administered in artificial respiration causes the patient to resume voluntary breathing more quickly. Experiments with plants in greenhouses also indicate that growth is accelerated by increasing the carbon dioxide content of the air.

AN EDUCATIONAL FABLE*

Once a Teacher introduced a New Student's Dictionary into one of his Lower Classes. When the Books came, he distributed them, and everybody was as keen as if they had been new Toys. Suspecting that the Pupils were none too Wise with such Books, the Teacher gave a little Preliminary Lecture on Alphabetical Order and such things, winding up by saying: "If this were a big Dictionary, you would find a lot of foreign Words after the words you look up. They would show what it was in other older languages. But in this Little Dictionary we shall find only the abbreviation that tells what part of speech the word is, and then the definition, in which its meaning is given in the plainest and simplest words possible. Now some one suggest a word to look up." And as no one spoke, the teacher said the first word that came into his Head, which happened to be "Pearl." They all hustled, and found it.

"And now, Charles," said the Teacher, picking by chance the dumbest Boy in the class, "get up and read for us what a Pearl is."

Charles rose and read, or appeared to read, but no words came from his Mouth.

"Hurry up, Charles," urged the Teacher.

"I—I can't read it," averred Charles.

"Oh, Nonsense; don't be stupid," said the Instructor. "Bring it here and I'll read it."

And this is what was written: Pearl (*n*). A Calcareous Concretion formed by the Deposition of a Nacreous or Mother-of-Pearl Substance around a Central Nucleus.

Moral 1: *It was one on the Teacher, but who would have thought the Dictionary would let him down in that way?*

Moral 2: *Now write a better definition of Pearl in the space provided here. Pearl (noun).*

* "Educational Fables," Edward C. Durfee, *Scribner's*, **84**, 329–33 (Sept., 1928).

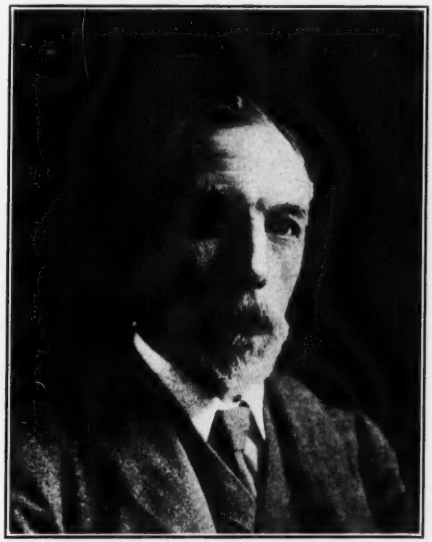
Synthetic Jewels Shown to Chemists. "No free samples!" was the caution to the audience at the recent Institute of Chemistry of the American Chemical Society, when they were shown various types of synthetic gems by Frank B. Wade of Indianapolis.

Mr. Wade reviewed the history of the making of gems, from the first much-disputed rubies from Geneva in 1885 to the present time, when chemically genuine rubies and sapphires have become commonplaces of the market, and even the most prized of all sapphires, the clear blue, can be produced at will.—*Science Service*

SOME USES FOR ATMOSPHERIC GASES

LAZY ARGON PUT TO WORK*

In September we spoke of the difficulties encountered in eliminating the last vestiges of water vapor from the inside of an electric lamp.[1] This has not been the only problem of the lamp maker. In order to prevent chemical action on the filament and the loss of energy by heat conduc-



Sir William Ramsay who, with Lord Rayleigh, undertook to find out why nitrogen prepared from air had a molecular weight different from that of nitrogen prepared from nitrogen compounds, and consequently discovered argon, neon, krypton, and xenon. Ramsay also discovered helium.

(From Bruce's "High School Chemistry," copyright, 1928, by the World Book Co., Yonkers-on-Hudson, N. Y.)

tion, efforts were made to attain as high a vacuum as possible. High vacuum, however, did not prove to be the right answer, for the metal sublimed from the white-hot tungsten filament and deposited on the cooler walls of the bulb, causing blackening. Some gas which would neither attack the filament nor be decomposed by high temperatures was

* See "Accomplishing Much by Doing Nothing," Guy Bartlett, THIS JOURNAL, **4**, 1376–85 (Nov., 1927).

[1] "Water, Water Everywhere," THIS JOURNAL, **5**, 1167 (Sept., 1928).

needed to set up a pressure within the bulb and so prevent the sublimation of tungsten. The rare and inactive monatomic gas, argon, was found to be the element needed. Improved processes for the fractional distillation

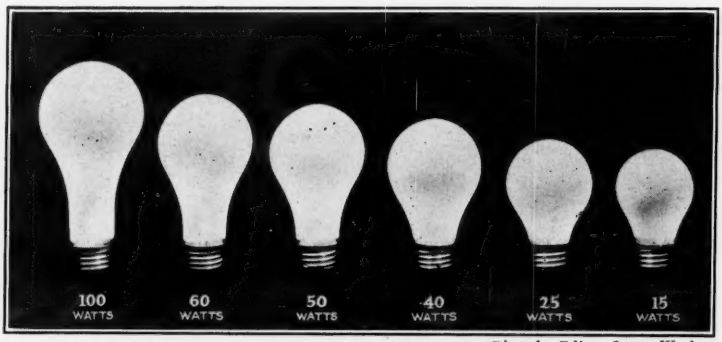
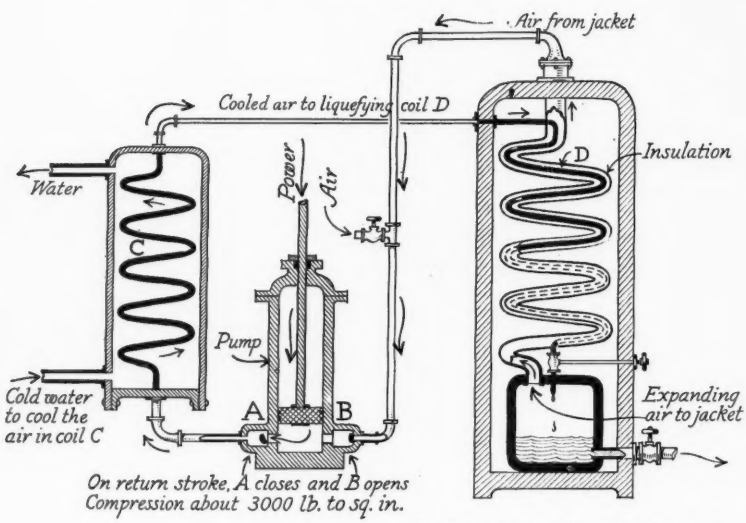


Photo by Edison Lamp Works

THE INSIDE-FROSTED, GAS-FILLED LAMPS OF TODAY

of liquid air have reduced the cost of argon from $10.00 per cubic foot to a few cents per cubic foot. It is now an invisible but highly important component of the common electric light bulb.



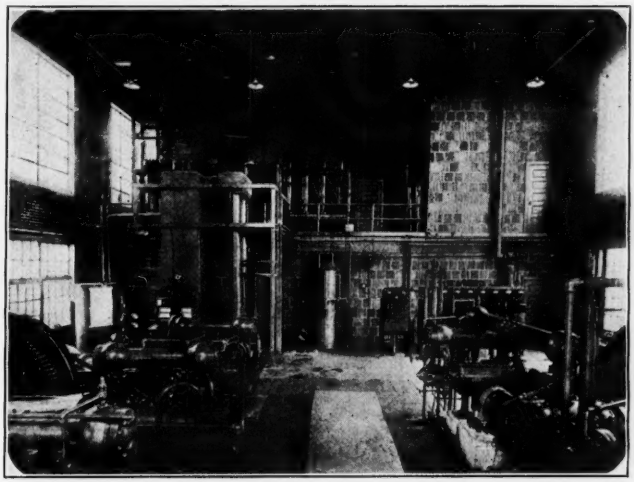
World Book Co., Yonkers-on-Hudson, N. Y.

DIAGRAM OF APPARATUS FOR LIQUEFACTION OF AIR

COMMERCIAL USES OF HELIUM GAS*

Helium gas, which has heretofore been considered a rare element and not obtainable on the open market, is now available in commercial quantities. Unusual interest is being manifested in its physical and chemical characteristics in the field of science and, because of its unusual properties, it is expected that new fields of usefulness will be discovered and developed for the benefit of industry.

The story of helium affords a striking example of the way in which unexpected values accrue from fundamental research. The gas was first



HELIUM PURIFICATION PLANT OF BUREAU OF MINES AT LAKEHURST, N. J.

discovered in the sun through spectroscopic observation by Janssen and Lockyear at the time of the solar eclipse of August 18, 1868. In 1895, Ramsay, searching for additional sources of the newly discovered element argon, discovered traces of helium in the mineral cleveite. Later, sources of helium were found in Canada and still later in France. It was observed that helium was always found in natural gas in the vicinity of minerals of a radio-active nature. During the World War, Doctor Ramsay suggested to our war department that they seek helium in certain natural gas fields where the radioactive minerals were present. His theory proved to be correct and the search for helium was successful. An extraction plant was then erected in Texas to supply helium exclusively for the use of the United States Government.

* From *Chemicals*, **30**, 16 (July 9, 1928).

More recently, helium has been made available commercially by the discovery of new natural gas fields having a higher helium content and the development of an improved process of extraction by The Helium Company whose plant is at Dexter, Kansas, with headquarters at Louisville, Kentucky.

The first and most important use of helium to date is for inflating dirigible and passenger balloons of the Shenandoah and Los Angeles type.

Official Photograph, U. S. Navy

THE HELIUM-FILLED *Los Angeles* CRUISING OVER MOUNT VERNON

Because of the fire and explosion hazard, the use of a combustible gas for inflating passenger balloons has been banned by the U. S. Government. Helium is absolutely non-inflammable and its lifting power is but little less than that of hydrogen. Because of these two characteristics—lightness and non-inflammability—it is also being used extensively for filling toy balloons that float in air for advertising, entertainment, and amusement purposes.

Another development is the use of helium to make a synthetic atmosphere of oxygen and helium for deep sea diving and caisson work involving labor under abnormally high pressure. The use of helium for this purpose minimizes the danger of "the bends" or "caisson sickness." This extremely painful and sometimes fatal ailment is believed to be due to the release of

nitrogen previously dissolved in the blood due to excess pressure. The advantage of helium in this instance is that it is not only more inert than nitrogen, but has the lowest solubility in water of any gas known. The tendency therefore is to increase the limits of the pressure at which work of this kind can be performed, permitting greater depths in diving work, for instance. It also lessens the time of compression and decompression of the operator, which is an important factor.

Helium not only has low solubility in water, but it is also practically insoluble in molten metals. For this reason, it is used in preference to other non-oxidizing gases such as nitrogen and hydrogen, in annealing processes and metallurgical operations. It is also used as a damper for nautical and other scientific instruments because of its high viscosity, which is greater than that of air, its high thermal conductivity, which is more than six times that of air, its high specific heat, low dielectric constant, etc. It is being used for filling radio tubes and glow lamps and tubes for signs and as a cooling medium in electric transformers and high speed generators. Helium has the lowest boiling point known, —267.9°C.

Drying is another field in which helium can be utilized to speed up operations and make products of superior quality. Water and other solvents have a higher vapor pressure and consequently will evaporate more rapidly in an atmosphere of helium than in the air or a vacuum.

OZONE*

Of the various chemicals made from air as a raw material, none is more interesting than ozone. It is a gas of powerful odor when concentrated, but pleasant and refreshing in great dilution, reminding one of country air after a thunderstorm.

This gas is best generated as nature makes it—by the action of a high-tension electrical discharge upon the oxygen of the air. Machines are now available which can deliver ozone on a large scale, in one-half per cent concentration, for under 30 cents per pound for the ozone, including interest and depreciation. It is thus to be considered as a moderately priced industrial chemical.

Ozone already has several interesting commercial applications, but it seems that its use could well be extended.

Ordinarily, air used for ventilation is discarded because it becomes stale-smelling, rather than because its oxygen content is appreciably reduced or its carbon dioxide content becomes too high. This results in high heating costs. Ozone freshens up stale air and makes it safe and refreshing, resulting in economy and satisfaction, particularly in department stores, libraries, and congested spaces, in general. A bad egg has

* From the *Industrial Bulletin* of Arthur D. Little, Inc., Cambridge, Mass., September, 1928.

little unfavorable influence on its neighbors in the ozone-purified air of a storage warehouse, for the transmission of flavor from egg to egg is suppressed. The air of such a warehouse may be fairly moist, thus resulting in little loss by evaporation, and yet mold formation will be prevented. Ozone is used for deodorizing hair, feathers, and other animal materials. Possibly laundries could use it to advantage in whitening clothes.

Water can be purified economically by ozone for drinking purposes. Swimming pool water may be kept fresh and clean by its means. It is used in bleaching beeswax and certain inedible oils. It is employed in the manufacture of vanillin, and, we understand, also of piperonal and anisic aldehyde. It practically doubles the drying speed of oxidizing oil paints, varnishes, and certain inks.

For applications where it is inconvenient to use ozone in the gaseous condition, it may be put into what amounts to solution form in pine oil or eucalyptus oil. Also, the gas may be applied hot or cold, under pressure or in partial vacuum, and in low or moderate concentration, giving a wide range of effects.

NEON ARC LIGHTS*

A brilliant red arc light which makes use of the rare atmospheric gas neon, and which can shine through thick fog, has recently been developed.

Airplane landing fields will probably be among the first to make use of the lamp, for by outlining the fields with them aviators flying above through fog will be enabled to make a safe landing. Such an occurrence as that of Commander Byrd on his flight to Paris, when he actually flew over Le Bourget, but could not see to land, would probably be prevented.

Another possible use of the lamp is in photography, especially in colors. The mercury vapor lamp which gives a characteristically violet-colored light, has often been used for ordinary photography, but the unnatural pallor which it causes is a disadvantage, especially where colors are concerned. By combining the neon light with the mercury vapor lamp, the former supplies the red rays which are lacking in the latter, and the result is a good approximation to white light.

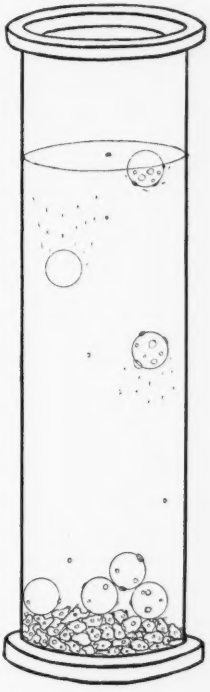
* From *The Crucible* of the Pittsburgh Section of the American Chemical Society, **12,** 132 (Sept., 1928).

Stimulus to Invention. "The world has too much conformity. What we need is more variety, more contrast, and, above all, more originality."—*Luigi Pirandello*

ODD EXPERIMENTS

The Synthetic Hatchery

On page 1350 of the abstract section of this number a density demonstration is described. Many ingenious experiments based on density have been devised, but one of the simplest and most striking is that known as "the synthetic hatchery." For this experiment a glass cylinder or battery jar, a handful of mothballs, a handful of mossy zinc, some ordinary table salt, a little sulfuric acid, and water are necessary.



A solution of table salt and water is made up to such density that a mothball placed in the solution will just sink. The mossy zinc is placed in the bottom of the glass cylinder and sufficient salt solution is added to fill the cylinder about three-fourths full. A little sulfuric acid is added to the solution—enough so that bubbles of hydrogen begin to appear on the surface of the zinc. The mothballs are then thrown in.

At first the mothballs sink and as hydrogen is evolved tiny bubbles of the gas cling to them. Soon a mothball will have accumulated a sufficient coating of hydrogen to overcome the narrow margin of difference in density between itself and the surrounding salt solution, whereupon it begins to rise to the surface. Bubbles of hydrogen may detach themselves as it rises and it may return to the bottom without reaching the surface. If the mothball does reach the surface most of the hydrogen is lost there and it sinks to the bottom to repeat the process. When all the mothballs are in motion the effect is similar to that sometimes observed in the hatchery tanks of an aquarium.

Too many mothballs should not be used or they will collide with each other and lose their hydrogen coatings before rising very high in the solution. Too much acid should not be added at first. If there is not sufficient evolution of hydrogen or if the action begins to slow down after a time, a little more acid may be added.

A Chemical Weather Forecaster

The change in color of a cobalt salt with changing degree of hydration discussed by Mr. Sorum on page 1287, may be made the basis for a chemical weather forecaster. Filter paper soaked in a solution of cobalt chloride and

dried constitutes the indicator. When atmospheric humidity is high the paper is pink; when humidity is low it turns blue. The paper may be cut in the shape of a rain cape or umbrella and combined with a figure from an advertisement to form an attractive card.

STUDENT CONTRIBUTIONS

Is your chemistry club carrying on some worthwhile project? Have you, yourself, an interesting chemical hobby? Have you devised an original chemical toy or demonstration apparatus? Have you built a working model of a chemical plant or a piece of chemical machinery? Have you a chemical collection of any kind?

Tell us and other students about it in an article of not more than one thousand words. If possible, illustrate your article with drawings or photographs, or both. In preparing your manuscript, observe the directions to authors set forth on page 1206.

Ten dollars will be awarded the student contributing the best item received on or before November 15, 1928. Five dollars will be paid for any other articles accepted for publication. Address your contribution to the Associate Editor, JOURNAL OF CHEMICAL EDUCATION, the Johns Hopkins University, Baltimore, Md.

Watch the November JOURNAL *for lasts month's prize-winning contribution.*

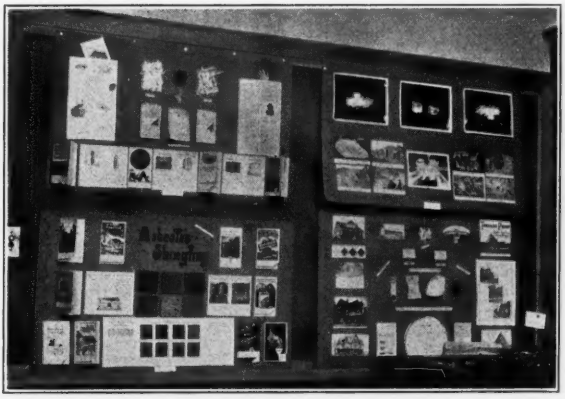
PUFFED RUBBER*

The list of exploded products, which started with puffed rice and wheat, and to which exploded wood (Masonite) was recently added, now includes puffed rubber. Puffed or "foam" rubber differs from the familiar sponge rubber in that it is even lighter, being only one-fourth as heavy as cork, is much less permeable to liquids, and has greater resiliency. It is exceedingly fine-textured. When the gas used during the vulcanization for the inflation of the rubber is carefully chosen for its chemical inertness, and the rubber itself is stabilized against oxidation, there would seem to be no reason why this lightest of all known solid substances might not stand up in service for years. It has qualifications which are practically ideal for life preservers, heat and cold insulation, and has been suggested as usable for stuffing upholstery.

* From the *Industrial Bulletin* of Arthur D. Little, Inc., Cambridge, Mass., September, 1928.

WHAT A CHEMISTRY CLUB CAN DO

In the August, 1927, number of THIS JOURNAL Mr. Clarence M. Pruitt discussed in some detail the organization of chemistry clubs and the activities which they can carry on.[1] We regret that space limitations prevent reprinting this article in full. Nevertheless, here are some suggestions in outline form.



ASBESTOS EXHIBIT ASSEMBLED BY STUDENTS OF RIDGEWOOD HIGH SCHOOL, RIDGEWOOD, N. J.

Program Hints for Regular Meetings

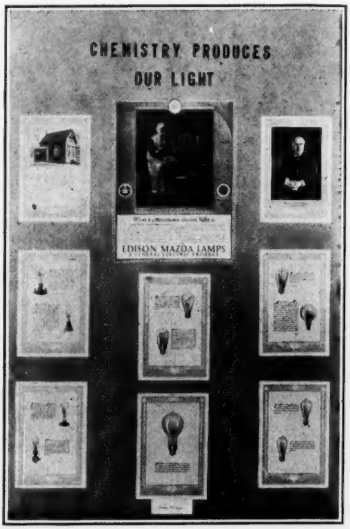
1. Talks by club members on the lives of famous chemists. Pasteur, Priestley, Lavoisier, etc.
2. Talks by members on the practical applications of chemistry.
3. Reports by members on current developments in chemistry.
4. Demonstrations of chemical magic or chemical hobbies by club members.
5. Chemistry spell-downs.

Special or Public Meetings

1. Displays of posters and chemical exhibits.

For suggestions see: "Chemical Posters," Adeline H. Jacobs, THIS JOURNAL, **2**, 792–4 (Sept., 1925); "Posters in Chemistry," Fannie L. Bell, *Ibid.*, **5**, 157–67 (Feb., 1928); "A Chemistry Exhibit," Fannie L. Bell, *Ibid.*, **5**, 280–90 (March, 1928); "The Chemistry Open House as an Aid in Instruction," Ralph E. Dunbar, *Ibid.*, **5**, 531–5 (May, 1928).

[1] "Activities of Chemistry Clubs," Clarence M. Pruitt, THIS JOURNAL, **4**, 1037–42 (Aug., 1927). Copies of back numbers can usually be obtained from the Business Manager, Wm. W. Buffum, 85 Beaver Street, New York City.



CHEMISTRY POSTERS MADE BY STUDENTS AT RIDGEWOOD HIGH SCHOOL, RIDGEWOOD, N. J.

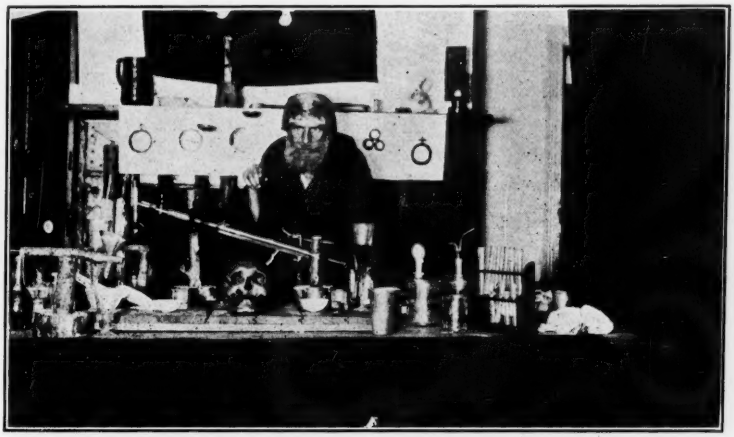
SOAP PRODUCTS DISPLAY ARRANGED BY STUDENTS OF DAKOTA WESLEYAN UNIVERSITY, MITCHELL, S. D.

2. Chemical playlets and vaudeville sketches (preferably written by club members).

See: "The Cinderella of the Metals," M. Elizabeth Farson, THIS JOURNAL, **2**, 57–61 (Jan., 1925); "Interference—A Chemical Play," Dorothy Ruddick, *et al.*, *Ibid.*, **4**, 905–7 (July, 1927); "Illustrating the Black Art," R. D. Billinger, *Ibid.*, **3**, 897–902 (Aug., 1926); "A Night in Alchemy," R. D. Billinger, *Ibid.*, **5**, 715–24 (June, 1928).

3. Outside chemists as speakers.

Many chemists are willing to take time from their personal affairs to address student organizations either free of charge or upon payment of traveling expenses.



THE ALCHEMIST AS IMPERSONATED BY R. D. BILLINGER

No doubt the secretary or chairman of your local organization can assist you by suggesting speakers. (See pp. 4 and 5 in the front of the JOURNAL.)

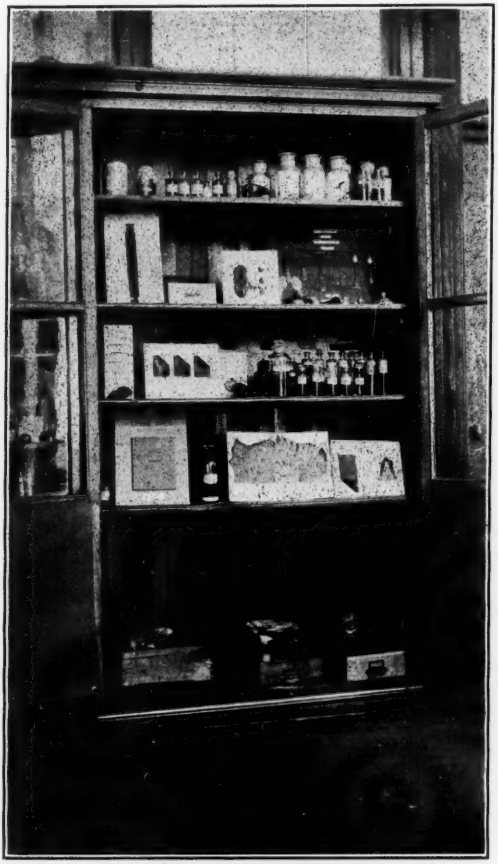
4. Timely programs, *e. g.*, Fire-Prevention Week.
5. Moving pictures.

Many films can be obtained merely by paying transportation charges. For possible sources of films see "Motion Pictures for Science Classes" on page 1294 of this issue.

Other Activities

1. Excursions to chemical plants with subsequent reports and discussions.
2. Making chemistry posters.
3. Construction of permanent apparatus or equipment to be left as gifts to the school.
4. Maintaining a bulletin board for the display of timely chemical material.

5. Keeping a chemistry scrap-book for the preservation of material of permanent value.
6. Collecting charts and other exhibits.

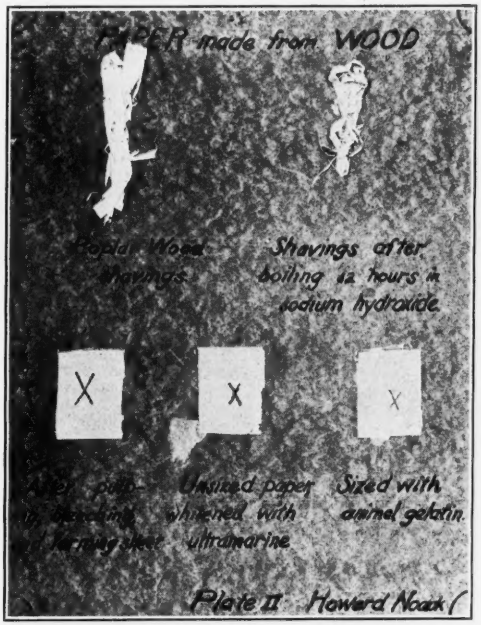


SECTION OF A CHEMICAL MUSEUM, MANUAL TRAINING HIGH SCHOOL, NEW YORK CITY

See: "Sources of Free Material for Use in the Teaching of Natural Science," University of Oklahoma Bulletin, New Series No. 314, University of Oklahoma, Norman, Okla. Also abstract entitled "Commercial Material for Science Classes," on p. 1350 of this issue.

7. Writing A. C. S. Prize Essays.
8. Chemical projects.

See: "Students' Research Work in High-School Chemistry," Hattie D. F. Haub, THIS JOURNAL, **4**, 1241–59 (Oct., 1927); "Chemistry Projects in High School," J. E. Manhannah, *Ibid.*, **5**, 1112–6 (Sept., 1928).



PAPER EXHIBIT WITH SAMPLES MADE BY A STUDENT OF ROOSEVELT HIGH SCHOOL, OAKLAND, CAL.

Let Us Help You

Write and tell us what your chemistry club is doing. We shall be glad to help by suggesting sources of information, material, etc. Address all queries to the Associate Editor, JOURNAL OF CHEMICAL EDUCATION, The Johns Hopkins University, Baltimore, Md.

SPECTRA OF THE ATMOSPHERIC GASES

Eimer and Amend are marketing an ingenious piece of demonstration apparatus devised by the Air Reduction Company. It consists of eight spectrum tubes mounted in a glass-fronted wooden display case. Each tube is filled with one of the elemental gases of the atmosphere. The set can be operated on five or six dry cells, connected in series. E. & A. Bulletin No. 404 describes the apparatus and contains a picture in colors of the set in operation.

Correspondence

THE BULLETIN BOARD

For those who are making regular use of bulletin boards as a means of supplementing their lectures and classroom exercises, let me call attention to the splendid material in the advertising pages of some of the journals. Every number of *Industrial and Engineering Chemistry* contains at least four or five pages of interesting and educative advertising suitable for posting on a bulletin board. Items to be found include: methods of manufacture, new chemical products, new uses for old products, properties of materials, bits of interesting and important history.

The JOURNAL OF CHEMICAL EDUCATION also carries a considerable amount of advertising which may be used in this way.

One need not be concerned over the ever-present "sales campaign" for students are quick to separate the important from the non-important. Use of such illustrative material as this calls to mind Professor Chamot's contention that quite as much fundamental information is often to be obtained from the study of manufacturers' catalogs as from perusing a textbook.

BROWN UNIVERSITY
PROVIDENCE, RHODE ISLAND

N. W. RAKESTRAW

EQUALITY AND SIMILARITY IN CHEMISTRY

We characterize any object by the sum of its properties. Though two (or more) objects are never entirely alike, we nevertheless look upon them as being alike even if they can only be said to be "similar." Two chicken eggs, two leaves of the same plant, two crystals of snow, are to all appearances similar, but never alike in every detail. This seems to be a very obvious statement, it may even be termed trite. However, we chemists should keep this fact very much in mind, when we claim equality for two or more substances from a chemical point of view. I venture to ask the question: Did any one of us ever stand before, or possess, two beakersful of distilled water of which he was sure that the two equal quantities were really alike in every detail? The answer cannot be but doubtful. And, if this be true for water, it will likewise hold for any other substance which may be chosen for a comparison. We do not go as far as all that. We are satisfied that the water in each case will show the same freezing point, and, under the same conditions of experiment, the same boiling point. It will at

definite temperatures dissolve equal amounts of water-soluble material, and so forth. It will, above all, when subjected to electrolysis, furnish hydrogen and oxygen in definite volumes; it will give us hydrogen when treated with the alkali metals. All of which satisfies us that we have in both cases the same substance—water—before us. A reasonable sum of properties suffices for our proof of statement of equality. And we let it go at that. We state that when we find this sum of properties, we have to do with water pure and simple. But, nevertheless, we must not forget that we have actually only stated a case of similarity. One more case of presumable superfluity of evidence is to be mentioned. Has any one ever in a case of water of crystallization really identified such water? The alums would furnish abundant chance for such an example of neglected research.

After all, we may state that, though chemically pure water is a substance rarely, if ever, met with, we are fairly sure in identifying water by its properties. We have intentionally taken water as a substance to start with, due to the simplicity of the case. What we have considered so far may be termed a preamble. We are driving at something more complex. And, in order to gradually arrive at that, we go back to those objects which we term elements. Let us, for argument's sake, define an element as a substance which will show a definite spectrum, such as will not be shown by any other object. Also here, we find from the start that the ideal case will seldom, if ever, materialize. Let us neglect the minute quantities of pollution. We know that chemical purity does not exist. But a grave problem arises outside of that. It is the fact of what we term allotropy. We claim for sugar-carbon, for graphite, and for diamond the elementary state. We claim that all three are carbon. Imagine a non-chemist before whom you spread in three different portions, say, lampblack, graphite, and a perfect diamond, and tell him with the most serious face of the world: now these three objects are all one and the same thing. Would not our friend, the non-chemist, look to you as if at one slightly demented? Would he not ask: how do you make that out? And if you told him that by some sort of complex reasoning you can prove to him that all three of these substances will yield upon combustion the same carbon dioxide, he would be by no means wiser. Suppose they do, he might reply, does that belie the fact which I perceive with my eyes, that these three substances are as different from each other as night and day? You would then tell him that carbon dioxide must of necessity be produced from something that is or contains carbon, since we cannot transmute the elements in such a manner as to obtain carbon dioxide from any other element but carbon. And, that since these three are in their entirety transformed into carbon dioxide, they must all three be exclusively carbon. Though, you add, we see from these facts that the element carbon can exist in three different

forms, or conditions, since the appearance and the readily recognizable properties of the three differ widely.

That is a bit of chemical reasoning which your friend may or may not understand, but which is valid for us chemists. You may further add that graphite as well as diamond can be prepared from the ordinary carbon, either, as for graphite, in the electric furnace or, for diamond, from the solution of carbon in fused iron.

For phosphorus the case would be just as phenomenal, considering the difference of the yellow and the red variety in behavior. Here, however, the transformation of one form into the other is more readily demonstrated. Let us assume (as is probably the case) that for all elements there exist such allotropic forms, where do our terms equality or similarity come in? We must assume such substances as similar (or equal) which, when brought together with a third substance, will produce the same fourth body. Thus, in this case one fact, and this one fact only, will prove similarity or equality.

And, finally, we approach those cases which are so abundantly found in organic chemistry and for which we have the term isomerism. Two (or more) substances which are different in all their properties, except in the one that they will yield upon combustion, say, carbon dioxide and water, to the same amount; both are considered as produced from the same ultimate elements.

Also here, the one fact of production of a fourth (and fifth) body counteracts all of the other observed facts of dissimilarity and makes the two isomers in a sense equal. And, in case of the existence of hundreds of isomers, all of them, in a sense, would have to be considered as equal or similar. Equal or similar in *what?* In one case of behavior only. Why is it that this one case of behavior overshadows all of the other cases of dissimilarity? As we stand here before a multiplicity for which we ignore the real cause, we have attempted to hypothesize a cause, but let that not lead us astray; let us rather state that we have no measure for equality and similarity in chemistry, that we are far from understanding the scope of possible multiplicity in chemical interaction. Percentage of elementary matter which we can get out of a given substance in the form of a new substance, will not tell us anything clear and new about our great variety of isomers.

601 W. 148TH STREET,
NEW YORK CITY

L. H. FRIEDBURG

One of our correspondents desires information relative to John Harrison (1773–1833), one of the earliest manufacturing chemists in the United States. Any suggestions will be appreciated.

Chemical Digest

COMPANIONATE EDUCATION*

There are very few of us who from time to time have not had some catchword or phrase which seemed temporarily to have panacean application. And, as is frequently the case, we have found that the expression so used was quite often more applicable to other circumstances than the original one for which designed. Such an adjective is "companionate" which, according to Joseph Jastrow in a recent issue of the *Forum*, has a much greater significance when applied to the educational field than to the marriage relation, in which the word has a questionable pertinence.

After indicating numerous guises that "companionate education" has thus far assumed, the author defines the term to mean—

> . . . taking the pedantic, didactic, institutional, formal, testing, examining, grading, flunking, degreeing, nursing, disciplining, rewarding temper out of the teaching relation, and putting into it the companionate animus of fellow-students pursuing a common interest—the few chosen leading and stimulating, and the many called eagerly following, yet companions all in a joint enterprise.

In venturing the idea of a companionate lecture, the reader's attention is called to the fact that the French have no word for a lecture but call it a *conférence*, and that the hearers do not attend but *assist at* a conference. However, the author is not proposing that the schools be closed at once in favor of companionate institutes of learning, for we read:

> Schooling is indispensable so long as immaturity is the natural condition of the young for a deplorably long period. But it is most unfortunate that, because boys and girls go to school to learn, or to prove their resistance to learning, the teacher-and-pupil relation should be fixed and limited to that condition. Under a prevalent view, living is made to begin where schooling ends, and school ends where life begins. To broadcast the companionate idea that stimulating contact with creative and inspiring minds is an integral part of an adequate adult life, and not for the few but for the many, is an ambitious programme, perhaps too large an order for one adjective to fill.

Believing that an adjustment in the teacher-pupil relation mentioned above would lead to a more general acceptance of companionate education, the author suggests:

> The formidable task that the ministers (not the administers) of education face is to liberalize this teacher-pupil relation, to alter its complexion radically, to denature it of its schoolday context, to renature it upon the mature pattern of companionate direction.

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* *Forum*, **80**, 244–9 (Aug., 1928).

However, there are difficulties.

"Teacher," though not beyond redemption, is a pretty difficult word to rehabilitate, and "pupil" is even more hopeless. Professoring has a presumptuous or an unctuous flavor and has almost become the proprietary perquisite of dancing masters. We are sadly in need of a refurbished educational vocabulary which will abolish in one imperious, destructive stroke this Freudian implication of superiority and inferiority that inheres subconsciously in the teacher-pupil relations, and will transform it to the setting of the mature in interest, purpose, and experience.

On reading further, we find some of the recent attempts at remodeling the present educational structure brought to our attention.

The educational structure is a glass house, and stones have been so freely hurled from within and without that every façade shows broken panes. Yet, underlying the several plans for reconstruction or redemption is the sensed incompatibility of the two ideals and the accompanying spirit and procedures—the one of schooling, the other of companionate education. The confusion of college and university has its roots here; in America the "universities" in name are inevitably both in fact. Here and there an isolated institution may attempt a completely graduate school and with some approach to the companionate ideal. But for the most part the college-university or university-college faces the compelling situation that it ministers to the transitional period in which pupils are emerging from dependent imitators into companionate thinkers.

The junior college is a proposal to facilitate or segregate this adjustment by providing separately for those who must be, or prefer to be, content with the former status, and for those eager and ready for the latter. It seems a promising part solution in many ways. The experimental college—whether of the pattern of Mr. Meiklejohn's or some other remodeled structure—though presenting a differently oriented programme, invites the companionate relation at an earlier stage. And much of the legitimate criticism of college instruction is directed precisely against the prolongation of such schooling methods to minds that are, or if properly selected should be, ripe for companionate pursuits.

Recently the University of Michigan announced a project to bring the alumni back to a companionate status and establish for them just such courses as would appeal to mature worldly interests, thus unexpectedly providing an illuminating contrast to the undergraduate procedure. Amherst has, in a measure, set a precedent for the proposal, and a provision at Vassar College, through the generosity of a bequest, has taken a step in the same direction. Companionate education, though mainly expressing the reality of a need, gives promising indication of a varied and ready clientele.

As for the present status and future development of this movement, we read:

The companionate following has so far shown a far readier eagerness for this educational enterprise than the companionate leadership. And a further canvass, particularly in the great busy centers, will rapidly swell the census of enrolment in so vitally democratic a cause. The larger clientele and the possibilities of establishing workable patterns of companionate education are inevitably dependent upon the mass interest of intricately coördinated groups of men, sensitive to the need of guidance in the problems of their occupations and their reflections. One must turn to the cosmopolitan outlook itself for the source of such leadership, for a course of study and establishment of effective opinion in the companionate temper.

. . . . Companionate education continues the authentic tradition inherent in the university as such a company of companionable scholars. In these progressive days such a microcosm of leadership must reflect and take its purpose from the macrocosm of its setting. However important the platform, a more intimate contact of creative minds must be established and favored. Companionate education requires a nucleus, a definite center of radiation and expansion; and central to that nuclear development is creative effort and research, as well as application. A companionate institution will be in no way aloof or remote or esoteric; it recognizes the public source of its vitality and assumes its responsibilities in response to it.

It is, indeed, a school, but equally a companionate "center"—a habitation fitter and richer in connotation than the "social center." This implies a group of men for whom it is the way of generations to come and go, such a nucleus implies a companionate discipleship in which the torch is handed on to younger bearers in fact and not in symbolic ceremony. Its companionship reaches out to the many-sided interests of men of affairs, breaking down the barrier between the university and the universe, companionating them likewise in its humanistic endeavors.

And do we not agree with Joseph Jastrow that the educational movement involving "adult education" or "post-school education" might aptly be called "companionate education?"

M. W. G.

CONFLICTING PRINCIPLES IN THE TEACHER*

For several years teachers have profitably used a book entitled "Conflicting Principles in Teaching and How to Adjust Them." Robert Clark in a recent issue of *Education* suggests that conflicting principles in the teacher, which he has not always known how to adjust, have often been a source of common troubles. The conflicts which arise most frequently are, according to the author, in regard to:

(*1*) *The Profession.* Some of the great educators believe that the teacher should represent an aristocracy—that is, the best in character, professional training, teaching ability, yes, and so far as possible "family background." But when we see so many teachers in high school, and even in the university, lacking in more than one of these qualifications; when we observe many of the pupils in our normal schools and higher schools of education, and many of those who are graduated, and realize that these institutions for the training of teachers are open to all, even to those lacking in high ethical and professional ideals; yes, and know that ideals and idealism are often taboo—"they are not practical"—well, we wonder. The inner conflict seems to be: Should the teaching profession be a limited aristocracy?—or an open democracy?

(*2*) *The Colleagues.* Principle one declares: the successful work of any institution is done where there is a unity. But this is likely to conflict with principle two: that teacher will teach best ("all other things considered") who has "an eye single" to his own subject; and in a large institution it is not always possible to have unity, or even harmony. So far as his fellow teachers and their departments are concerned: should he be esoteric or exoteric?

* *Education*, **49**, 48–53 (Sept., 1928).

(*3*) *The Executive.* Here are two principles in conflict: the principle that the official head is in control of the institution and the individual teacher should work along the lines of his policy and ideals and program; this is often likely to conflict with the principle that every well-trained teacher is best fitted to do his own work in his own way. But suppose the chief is not sympathetic to either subject or method, but permits both, and the teacher honestly is convinced that he can do his best work most efficiently by his method, at that place? And when it comes to radical differences in fundamental, moral and educational principles? Here indeed is a conflict between self-expression and self-suppression.

(*4*) *The Teaching Itself.* Is it better to teach in such a way that the subject is thought about and the teacher, as a teacher, is not thought of, or does not that teacher have the greatest influence—he surely has the greatest power—who impresses upon his pupils his worth as a great teacher? The principle that the fundamental factor in teaching is the teacher often conflicts with the principle that the fundamental factor in teaching is the truth taught.

(*5*) *The Pupils.* The principle that the student needs sympathy, and the greatest influence of the teacher comes when there is personal sympathetic interest in the pupil, often conflicts with the principle that for successful work in any institution there should be much harmony and little fault-finding, and one's colleagues should be upheld as a matter of policy and loyal support. Could not the teacher be a more helpful friend to his pupils if he were a little less loyal to his colleagues? What should be his attitude toward his pupils—that of an intimate friend? Should this attitude be in the classroom, or confined to life outside? Here is a conflict within a conflict. Is the greatest value of a teacher in that of a personal friend or that of a professional expert? If that of the friend, then the sympathetic friend, or a friendship limited by professional restrictions?

With these comments before us, the task of settling or adjusting the conflicts seems a difficult one. In conclusion, the author suggests:

> Sometimes there is an impulse to bury ideals and over the grave inscribe: Here *Lies* a Teacher. Ideals may often be put to sleep, but seldom buried alive. Principles, when the truth, "though crushed to earth *will* rise again." But are the principles of the individual teacher truth?

And so the conflicts in the teacher continue and never are adjusted satisfactorily, finally, permanently. And should they be?

M. W. G.

RESEARCH—THE BUSINESS BUILDER*

Doubtless the man in the street is already convinced of the value of industrial research. It is not difficult to appreciate the value of those investigations which have such practical applications as to lend their results to immediate commercialization. But of what interest to the business man are problems of pure science which have no apparent bearing upon his business? Of what interest is it to him that Dr. Albert A. Michelson, of the University of Chicago, although recognized as the world's foremost authority on light, is, at the age of 75, devoting his energies to the problem

* *Scribner's*, **84**, 345–51 (Sept., 1928).

of making more accurate the astronomer's yardstick, which at most is off by only 10 miles in 186,173? "Pure" science, and not practical, applied science, is the driving force behind such an investigation. However, business cannot afford to hold in disdain this "pure" science, according to Silas Bent, in a recent issue of *Scribner's*. In fact, he states:

> All industrial research is the child of pure science, for it consists in the application of discoveries valueless (in dollars) when they were made. Faraday spoke better than he knew when, defending himself ironically from a government official who asked what was the use of his experiment with electromagnetic currents, he retorted that some day the product might be taxed; last year a single electrical concern in the United States paid an income tax of about $8,000,000.

On the other hand:

> "Impure" science pays dividends as well as taxes. More, it is now a crutch for research in "pure" science. Doctor Michelson could not now be carrying on his adventure in the measurement of light-speed if it were not for the help extended to him by an industrial research laboratory (which furnished the delicate apparatus required).

A non-technical description of the experiments being carried out by Dr. Michelson is given. Continuing:

> This is an example, by no means exceptional, of the dependence pure science acknowledges to its offspring, industrial research. Not long ago an erudite philosopher, referring casually to the research staff of a great corporation, observed that no American university could muster such an array of learning and culture. The laboratories of Big Business are often as highbrow as any academic grove. Here, on some lonely salient of the boundaries of knowledge, a worker or a group of workers, may pursue for months or years a faint clew which, in the end, may lead nowhere. There are many of these slender peninsulas into the unknown; and always there is the effort to straighten out the line of attack, and to consolidate such gains as have been achieved.

To substantiate his point, the author quotes some interesting figures concerning industrial research in this country.

> It is estimated that $200,000,000 a year is being spent in this country on industrial research, and that the government spends about one-third of this sum. Not long since, your Uncle Sam was engaged in 553 separate projects, 360 of which were coöperative, with eleven hundred concerns sharing in the expense. What is known as "the new competition," under which allied industries band together to capture markets from other trade associations—such as brickmakers from lumber dealers—means also a new coöperation. The coöperation is within the trade association, and manifests itself, for one thing, in research for the good of the whole industry.
>
> Two hundred million dollars is an eye-filling figure; but it amounts to only $1.74 per capita for the United States, whereas American industry spends $11 per capita for advertising, in the creation of markets and the search for them. Advertising appropriations, well placed, have an economic justification; but think how much money we spend more or less foolishly: $27 per person for joy-riding and pleasure resorts, $11 for candy, $5 for cosmetics. Corporations which maintain large laboratories assert that the return on their investment ranges from 500 to 1000 per cent. The American Telephone and Telegraph Company estimates that comparatively small improvements

in its equipment, through three years' research work, save it $12,000,000 annually, and expects this saving to be manifest year after year, so long as the present type of equipment is in use.

In this rapidly advancing age of ours we are not surprised to learn that the research methods of today differ from those of fifty years ago. We read:

> And research men work nowadays in groups. Time was when the scientist went off into a room by himself, fitted the door with a lock and threw away all but one of the keys. Then he tackled his problem in solitary grandeur. There are still a few who work alone. But it has been found that life is rather too brief for that sort of thing. Problems are too complex for one brain, functioning only through the span of mortal life; and there are times when more than one problem must be carried along simultaneously with others, progressing *pari passu* if the end is to be consummated. Thus a new technic has been evolved, whereby problems are divided and subdivided; their elements are assigned to individuals or to small coteries; so that chemists, metallurgists, mechanicians, and engineers may unite in a sort of shock troop to invade the no man's land of natural law.

The cable of the Western Union recently laid from New York to the Azores is cited somewhat in detail as an example of a result of this group work. Statements are also included relative to the application of research to industries in general. However, all research may not be universally profitable, for we read:

> The industrial laboratory may also cripple or kill a whole industry. The Victor Talking-Machine Company, for example, paid dividends for eleven years on its common stock of $42 a share, and in 1922 threw in for good measure a 600 per cent stock dividend. But with the development of radio in the research laboratory, and the broadcasting of musical programmes, the demand for victrolas fell off and the company passed its dividend. Only by pitting Greek against Greek could the day be saved. Research workers created a new and much improved talking-machine, capable of imitating the range and quality of the human voice and of whole orchestras in an unprecedented way, and the laboratory thus saved an industry which the laboratory had come near destroying.

Accomplishments of research workers in various fields are cited. On reading further, we find that the industrial research which is of the greatest value is merely a link in a chain. Maurice Holland, director of the National Research Council's division of engineering and industrial research, has set down the successive stages in the following fashion:

> First, there is the discovery in pure science, which may never be convertible into dividends; then there is the scientific application of this discovery, if it can be applied; then there is the invention of a device; then there is the employment of the device in industry; then there is a process of standardization; then there is mass production. This he calls "the cycle of research."

The task of industry is to keep reducing the "time-lag" between the first step and the last.

It might be interesting to include the nations leading in industrial research today, with Mr. Bent's comments regarding the rôle which research plays in regulating trade barriers.

Germany, which was far in the vanguard before the World War, still holds the lead in industrial research. The United States is not a very good second, and England ranks third. German laboratories are generously subsidized, for the government believes in them now as firmly as before the war; and the same thing is true of Japan, which ranks fourth. It is a race not merely for knowledge but for the markets. We had an example of this when certain of our industries took fright at the prospect of competition in their own markets with methanol, a German-manufactured synthetic wood-alcohol, which could be sold here much more cheaply than our own product.

This was a lesson in tariffs as well as a lesson in research. It must be clear that no tariff wall can be built high enough to keep out the goods of a country which excels sufficiently in the economies and superiorities which come from successful and ingenious scientific investigation. International debts may do less than research in the long run to level international trade barriers. Research will level them, if at all, by making them useless for protective purposes.

In conclusion, aside from the political potentialities and commercial uses of the industrial laboratory already indicated, its educational implications are called to our attention.

It may influence, it may even deflect, the curricula of our higher institutions of learning. One of the problems now confronting great corporations is the problem of research personnel. Where are they to find men competent to fill the ranks of their expanding laboratories? Unless Young America can be interested in the work for itself, there will be a shortage of the chief raw material, which is human brains. Fat pay-checks are not enough. The research worker must be animated by something other than a desire for ample living. He must burn with an inward fire which money can't kindle. He must be so immersed in his task that he becomes, at times, jumpy and temperamental and hard to manage. And there is a large question in the thought of some of our captains of industry whether the American university is turning out enough young men with inquiring minds and a passion for the enlargement of knowledge to meet the increasing demand.

Between scholasticism and industrial research there is an interaction and an interdependence. The commercial laboratory lends a hand to "pure" science and to university investigators. Will the university reciprocate?

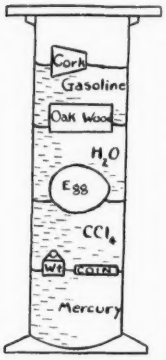
M. W. G.

Production and Consumption of Copper Sulfate in Italy. Italy outranks all other countries as a producer and consumer of copper sulfate, according to Assistant Trade Commissioner E. Humes at Rome. Production has increased from 31,000 metric tons pre-war to three times that quantity in 1926 with a productive annual capacity of 140,000 tons. Domestic production capacity is more than sufficient for home requirements and allows a considerable exportable surplus, but there is always a demand on the Italian market for copper sulfate in large crystals obtainable only from abroad. The foreign trade in 1927 registered an important increase, imports having increased from 8238 metric tons in 1926 to 12,800 tons, while exports advanced from 8086 to 10,826.—*Chem. Markets*, **23**, 214 (Aug., 1928).

ABSTRACTS

TEACHING METHODS, AIDS, APPARATUS AND SUGGESTIONS

A Practical Density Demonstration. RALPH E. DUNBAR. *Science*, **68**, 233 (Sept. 7, 1928).—"The differences in density of various liquids, the non-miscibility of these liquids and their buoyancy as expressed by Archimedes can be rather vividly demonstrated by use of the simple apparatus illustrated herewith; the liquids contained in an ordinary hydrometer jar are mercury, carbon tetrachloride, water and gasoline, each added carefully in turn to the vessel. Objects are added as each layer of liquid is introduced. These may include a brass weight and coin, egg, piece of oak wood, and cork which will float on the several layers of liquid, respectively. Gold or platinum articles will also sink in the mercury if added. When once this piece of apparatus has been arranged, it may be preserved for months, with the possible exception of the egg." G. H. W.



Commercial Material for Science Classes. ANON. *Sci. Classroom*, **8**, 5 (Sept., 1928).—The editors have communicated with numerous firms and have listed those which are willing to furnish material for science study. The chemistry list is as follows:

Allegheny Steel Co., Brackenridge, Pa.; Aluminum Goods Manufacturing Co., Manitowoc, Wis.; American Chemists Products, Rochester, N. Y.; The American Enameler, Franklin St. at Calvert St., Baltimore, Md.; American Hard Rubber Co., 11 Mercer St., New York City; American Instrument Co., 1214 D St., N. W., Washington, D.C.; American Paint & Varnish Mfgrs. Assoc., 1002 Public Ledger Bldg., Philadelphia, Pa.; American Sheet & Tin Plate Co., Pittsburgh, Pa.; Amoskeag Mfg. Co., Manchester, N. H.; Antihydro Waterproofing Co., Newark, N. J.; Armour Fertilizer Works, Chicago, Ill.

Bakelite Corp., 247 Park Ave., New York City; Barrett Co., 40 Rector St., New York City; Berry Bros., Detroit, Mich.; Carborundum Co., Niagara Falls, N. Y.; Carter's Ink Co., Boston, Mass.; Central Alloy Steel Corp., Massillon, O.; Carus Chemical Co., La Salle, Ill.; Crucible Steel Co. of America, 17 E. 42nd St., New York City.

The Duriron Co., Inc., Dayton, O.

R. J. Fitzsimmons Corp., 75 Fifth Ave., New York City; Fostoria Glass Co., Moundsville, W. Va.

The Gevaert Co., 423 W. 55th St., New York City.

Hammermill Paper Co., Erie, Pa.; Hammer Dry Plate Co., St. Louis, Mo.; Hercules Powder Co., Wilmington, Del.

The Ink-Out Mfg. Co., Montclair, N. J.; Inland Crystal Salt Co., Salt Lake City, Utah; International Nickel Co., 67 Wall St., New York City.

Jacoby Art Glass Co., St. Louis, Mo.

Karolith Corp., 2125 Forty-fourth Rd., Long Island City, N.Y.; Keasbey & Mattison Co., Ambler, Pa.

LaMotte Chemical Products Co., Baltimore, Md.; Linde Air Products Co., 30 E. 42nd St., New York City.

Magnus Mabee & Reynard, Inc., 33 Cliff St., New York City; Matheson Co., North Bergen, N. J.; Mellon Inst. of Ind. Research, University of Pitts., Pittsburgh, Pa.; The Miller Rubber Co., Akron, O.

National Bd. of Fire Underwriters, 207 Ohio St., Chicago, Ill.; The Nitragin Co., Inc., Milwaukee, Wis.; Wm. N. Nugent & Co., 410 N. Hermitage Ave., Chicago, Ill.

O'Hara Waltham Co., Waltham, Mass.; Oxide Battery Co., 1485 Marshall Ave., St. Paul, Minn.

Parker Rust Proof Co., Cor. Milwaukee Ave., E. & Dubois St., Detroit, Mich.; Pfister & Vogel Leather Co., Milwaukee, Wis.; Pittsburgh Plate Glass Co., Paint & Varnish Div., Frick Bldg., Pittsburgh, Pa.; Portland Cement Assoc., 347 Madison Ave., New York City; Powhatan Mining Corp., Woodlawn, Baltimore, Md.

Russia Cement Co., Gloucester, Mass.

Sapolin Co., Inc., 229 E. 42nd St., New York City; Strathmore Paper Co., Mittineague, Mass.

U. S. Gypsum Co., 17 State St., New York City; U. S. Industrial Alcohol, Inc., 110 E. 42nd St., New York City; U. S. Steel Corp., 71 Broadway, New York City; U. S. Bureau of Mines, Dept. of Commerce, Washington, D.C.

The Vacuum Oil Co., 61 Broadway, New York City.

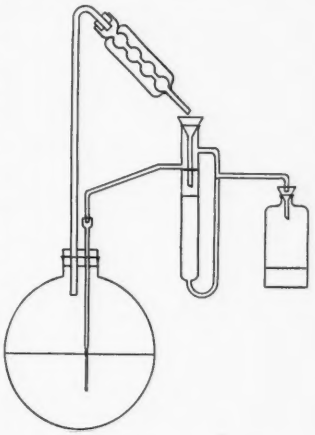
Whiting Paper Co., Holyoke, Mass.; Worcester Salt Co., 71 Murray St., New York City.

Wm. Zinsser & Co., 516 W. 59th St., New York City. O. R.

A Continuous Separator for Organic Liquids. *Synthetic Org. Chems.*, **1,** No. 4 (April, 1928).—"An automatic separator which finds many applications in organic preparations is shown in the photograph below. It can be used advantageously to separate two immiscible or partially miscible liquids which differ in density by more than 2 per cent.

"By combining it with an ordinary distillation apparatus, as shown in the diagram, one of the liquids can be returned to the boiling flask for redistillation without interrupting the operation. The heavier liquid can be returned by reversing the connections to the delivery so that the lower one leads to the flask and the upper to the receiver.

"The construction of such a separator is quite simple, as can be seen from the diagram. The size which we have found most convenient for our work measures about 200 mm. in length and is made of 20 mm. and 5 mm. Pyrex tubing. The side arm on the smaller tube is placed about 10 mm. (from center to center) below the one on the larger tube. Both of these arms should be at right angles to the vertical tubes, and must not incline upward at any part of their length.



"Before the separation is begun, the apparatus is partly filled with the heavier liquid to prevent the passage of the lighter liquid into the narrow limb. The suspension of liquids is then introduced through a funnel, which extends a short distance below the side arm. A description of this apparatus, together with some of its uses, is given in *J. A. C. S.*, **43,** 366 (1921), but the comments of visitors to our laboratory lead us to believe that its uses are not as well known as its convenience would warrant.

"We have used this apparatus very successfully in the preparation or purification of the following compounds: aniline, quinoline, salicylaldehyde, butyl ether, anhydrous oxalic acid, ethyl and butyl oxalates, and many others. It can also be employed for steam distillation without live steam, the separated water being continuously returned to the distilling flask." M. W. G.

Extraction Apparatus for the Laboratory. *Synthetic Org. Chem.*, **1,** No. 5 (June, 1928).—"The term extraction denotes the removal of definite constituents of a mixture by selective solution in some liquid in which they alone are soluble. Extraction falls into two classes, involving the treatment respectively of liquids and solids by liquid extraction media. The latter case will first be considered.

"The classical method of doing this involves the use of a Soxhlet extraction apparatus, in which the condensed solvent flows onto the mixture of solids contained in a paper extraction thimble of special construction which serves both as container and filter, while the filtered solution is periodically transferred to the boiling flask by means of an automatic siphon. This ingenious apparatus, in which the extraction is carried out at temperatures below the boiling point of the solvent, suffers from the disadvantage of permitting the extraction of only relatively small quantities, as the capacity of thimbles obtainable in the market is limited.

"The extraction of quantities of solids up to about 500 g. may conveniently be carried out without the use of a Soxhlet apparatus merely by placing the substance in a fluted filter paper in an ordinary funnel stoppered to a flask containing the boiling solvent. The wide end of the funnel is loosely closed with a round flask, of larger diameter than the mouth of the funnel, through which cold water is run (Figure 1). The vapor of the boiling solvent condenses on the bottom of this flask, and the condensed liquid falls upon the material to be extracted; after percolating through this, it filters through the paper and runs down to the boiling flask. In this way the extraction is carried out at the boiling temperature of the solvent without the use of special apparatus and without

particular attention. The water-cooled flask forms a surprisingly efficient condenser, and extractions may be performed even with ether without undue loss of solvent.

"A different type of apparatus must be employed for larger quantities of solids. The material to be extracted may be treated in a percolator; but, if this is not available, a satisfactory device may be constructed from a bottle of suitable size. This is filled to about three-quarters of its capacity with the solid to be treated, holding a wooden rod in position along the axis of the bottle during the process of filling. This rod is then carefully withdrawn so as to leave a channel into which a tube is inserted. The apparatus shown in Figure 2 is then assembled and the bottle nearly filled with the extracting liquid, which must have a density appreciably lower than that of the solid. A second portion of the liquid is placed in the boiling flask and gently boiled. The condensed liquid flows to the bottom of the mass and percolates upward, finally escaping from the exit tube and returning to the boiling flask charged with solute. Owing to the difference of the densities of the solid and the liquid, none of the former should rise with the upward stream of liquid to such an extent as to contaminate the outflowing solution. The extraction may be performed at any desired temperature (below the boiling point of the solvent) by surrounding the extraction bottle with a suitable bath. This system is not highly efficient from a thermal standpoint, but has the advantage of requiring very little attention.

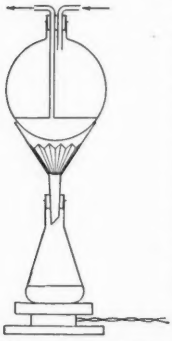


FIGURE 1.—Shows a simple apparatus for the extraction of solids up to 500 g.

"Extraction of substances in solution by immiscible solvents is usually affected in the laboratory by shaking in a separatory funnel of capacity sufficient to accommodate the entire quantity. When volumes larger than one liter are to be handled, and only two or three changes of solvent are necessary, the shakings may satisfactorily be carried out in bottles; the liquids are separated by siphoning the bulk of the lower layer, decanting the major portion of the upper layer, and completing the separation in a small separating funnel.

"When, however, more agitations are necessary to effect the extraction, continuous extraction permits great economy of time to be made. This operation is carried out exactly as in the extraction of larger quantities of solids in a bottle (Figure 2), the latter being filled to rather more than three-quarters of its capacity with the solution to be treated. Here, again, it is imperative that the solvent should possess a lower specific gravity than the solution. This apparatus is readily adapted to the extraction of amino acids by Dakin's method with butyl alcohol, though it is advisable to modify it by the introduction of an extra condenser, preferably in the form of a water-cooled flask (Figure 3).

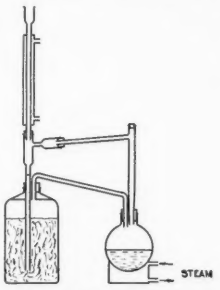


FIGURE 2.—Showing apparatus for extracting solids in fairly large quantities.

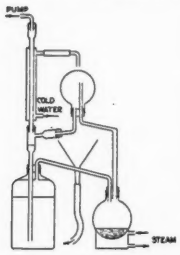


FIGURE 3.—Showing another modification useful in extracting amino acids by Dakin's method.

"The extraction of solutions by liquids of higher density is less readily adaptable to continuous methods in the laboratory." M. W. G.

A Method of Determining the Absolute Zero of Temperature. J. R. COTTER. *Phil. Mag. and J. Sci.*, **6**, 318–20 (Aug., 1928).—"At present the exact position of the absolute zero seems to be uncertain to about 0.1°. Kamerlingh Onnes obtained the value —273.09°, while Henning and Hense give —273.2°. Other calculations lie between these values."

Method (a modification of Kelvin's) with diagrams is described, which author believes would allow investigator to measure the position of the absolute zero with a great degree of precision.

Advantages claimed are: "(1) only one volume has to be measured; (2) the calorimetric conditions are ideal, since there is no radiation correction and no correction for the thermal capacity of the containing vessel; (3) the heat-energy is directly obtained

in ergs, so that Joule's equivalent is not required, as it would be in the method suggested by Kelvin."

"With this instrument the whole thermodynamic scale down to the lowest temperature could be reconstructed by using a succession of suitable liquids. Some modification would be necessary below the freezing point of mercury." M. W. G.

The High-School Science Problem. A. C. MONAHAN. *Am. Educ. Digest*, **47**, 489 (July, 1928).—Decreased enrolment in textbook sciences, with increased enrolment in laboratory sciences; increased cost of laboratory apparatus with a demand for decreased school costs sets the school adminstrator a difficult task.

The solution does not lie in the purchase of cheap furniture and apparatus. Cheap apparatus does not have a high degree of accuracy and is valueless from the educational point of view. Poor equipment means experiments that fail and that in turn means loss of confidence in the teacher, textbook, and course in general.

Furniture made by factories specializing in laboratory furniture is the best because those making it understand the technical requirements.

Building space may be saved by using the laboratory for lecture purposes. For physics and chemistry the "Lincoln Table" is recommended. It is T-shaped and used by two pupils one on each side with chemistry sink between them. A special chair is built for use with it.

In smaller schools one laboratory may be used for two or more sciences, providing care is taken to protect all physical apparatus from chemical fumes.

Efficient utilization of space that is furnished with equipment of greatest service and permanency is true economy in high-school laboratory fittings. J. W. H.

EDUCATIONAL MEASUREMENTS AND DATA

The Weaknesses of the Small High School. JOSEPH ROEMER. *Peabody J. Educ.*, **6**, 37–43 (July, 1928).—Latest reports from the United States Commissioner of Education give 50 per cent of the public high schools of the country as having 50 or fewer pupils enrolled and that 75 per cent had 100 or less enrolled.

Weaknesses listed for the smaller high schools are: Excessive teaching load, low teacher qualifications, poor distribution of teacher assignment, inferior teachers, limited, ill-balanced curricula, little pupil option upon subjects carried, and no vocational offerings. Equipment for playground, laboratory and library is meager, instruction poor, and there is slight opportunity for pupils to engage in student activities which are attractive to them.

Suggested remedy: Consolidate many of these schools and so increase expenditures upon them in order to make them attractive to a better qualified group of teachers.

B. C. H.

KEEPING UP WITH CHEMISTRY

What Is an Atom? P. R. HEYL. *Sci. Am.*, **139**, 9–12 (July, 1928).—The newest conception of the atom, known as the Schrödinger atom, is described and its fundamental nature explained. Consequently, the Bohr atom is outlawed. W. G. K.

The Inner Structure of the Atom. JAMES PATRICK. *Am. J. Pharm.*, **100**, 176–87 (March, 1928).—An abstract of an address given by Dr. Patrick, Aberdeen University, before the North British Branch of the Pharmaceutical Society. The following topics are discussed clearly and in non-technical language: brief historical review of structure of matter; electrolysis and conductivity; radioactivity; electron and proton; isotopes; planetary elections; Bohr's theory; Planck's constant. M. W. G.

Corrosion and Inhibitors. EDITORIAL. *Silicate P's & Q's*, **8** (Aug., 1928).—Silicate of soda has been found to exert an inhibitory effect upon the corrosion of lead, iron, and aluminum. Shaving soaps corrode aluminum collapsible tubes. One drop per tube of silicate of soda has been found entirely successful in preventing such corrosion by soaps and, on the other hand, in no way damaging the soap. It is suggested that the inhibition is due to the hold of the colloidal silicate upon the alkali in the soap.

B. C. H.

The Romance of Cookery. CHAS. H. LAWALL. *Am. J. Pharm.*, **100**, 128–55 (March, 1928).—A popular science talk delivered at the Phila. Coll. Pharm. & Science, 1927–28 season. M. W. G.

The Preservation of Food. LOUIS GERSHENFELD. *Am. J. Pharm.*, **100**, 201–32 (April, 1928).—One of a series of popular lectures given at the Phila. Coll. Pharm. and Science, 1927–28 season. Some of the topics discussed which might be of interest to teachers of elementary chemistry or science are: the first refrigerator; artificial ice; value of a variety of food; spoilage and destruction of food; methods other than refrig-

eration of preserving foods, including dehydration, sterilization, canning, and use of chemical preservatives. The preservatives listed, with properties and uses, are: nitrates, benzoates and salicylates, boric acid and borax, sulfites, sulfurous acid and sulfur dioxide, peroxides and hypochlorites, and formaldehyde. A few of the problems in the conservation of food are briefly discussed. M. W. G.

Metals in Our Food. FLINN AND INOUYE. *J. Am. Med. Assoc.*, **90,** 13 (March 31, 1928).—A summary of findings in the interesting study of the authors is as follows: Cu, Zn, Mn, Fe, Al, Ni and Co are commonly found in plant and sea food. Pb, a recognized body toxicant, is not.

"Cu, Zn, Mn, Sn, Fe, and Al are generally present in the human body, but with the exception of Fe do not have any known function in the vital economy of the organism.

"Cu, Ni, Zn, Sn, and Al are all attacked by acids or alkalis during the cooking process, the amount depending roughly on the acidity or alkalinity of the food.

"Cu, Zn, Al, and Ni are not classified as industrial poisons because of the absence of any evidence of chronic or acute poisoning in industrial plants. Ni poisoning has been reported from nickel carbonyl.

"There is no scientific evidence of any chronic poisoning taking place from food cooked in aluminum utensils. Large doses of Al salts, like Cu and Ni, will cause gastro-intestinal disturbances when excessive amounts are dissolved.

"Sn apparently does not affect the human system, but because of its cost its use in cooking utensils is prohibited." M. W. G.

Sulfur in Rubber Manufacture. D. F. TWISS. *Trans. Inst. Rubber Ind.*, **3,** 386–400 (1928). (Abstracted by D. F. Twiss, *Chem. & Ind.*, **47,** 649 (Aug. 31, 1928).)—"The fineness, solubility, and transformations of various forms of sulfur are discussed, and their bearing on manufacturing processes is indicated. When heated in admixture with rubber, $S\mu$ rapidly changes to soluble sulfur; for this and other reasons it is improbable that the effect produced by vulcanization is caused merely by the formation of a fine dispersion of insoluble $S\mu$ in chemically unchanged rubber (cf. Dannenberg, *B.*, **1927,** 564)." M. W. G.

Liesegang Rings and Periodic Precipitation. E. S. HEDGES. *Chem. & Ind.*, **47,** 710–2 (July 13, 1928).—Attention is called to the various theories which have been advanced to explain this phenomenon and the general lack of agreement among them. The work of Holker, not generally studied by those interested in the problem, seems to show that the size of precipitated particles varies periodically with the concentration of the precipitating agent. This is important and further work along this line is needed. E. R. W.

Sponge. Its History in Medicine with a Brief Account of Its Habit and Structure. J. T. LLOYD. *Am. J. Pharm.*, **100,** 232–9 (April, 1928).—Even before the beginning of the Christian era, the sponge, due to its iodine content, occupied a recognized place in medicine. Brief history of its use by various civilizations included up to 1830, at which time iodine (referred to as "spongia" previously) and its compounds received their first official recognition, being mentioned in both the Philadelphia and New York issues of the "Pharmacopoeia" of 1830. The three methods of reproduction ("budding," sexual, and "gemmulation") are briefly described. The general essentials of structure are also described. M. W. G.

The Rare Elements. FREEMAN P. STROUP. *Am. J. Pharm.*, **100,** 499–509 (Aug., 1928).—One of a series of popular science talks given at the Phila. Coll. Pharm. and Science, 1927–28 season. Elements briefly described with uses are: (1) *gases*, helium, argon, neon, radon (niton); (2) *metals*, beryllium (glucinium), titanium, chromium, tantalum, tungsten, cerium, thorium, and radium. M. W. G.

Pharmacy in Relation to Science. ED. MAYHEW. *Am. J. Pharm.*, **100,** 333–42 (May, 1928).—In the concluding words of the author he summarizes the content of the article.

"In giving this outline of the development of pharmacy I have, in effect, given an account of the early development of the science of chemistry. The debt that chemistry owes to pharmacy will readily be recognized, when it is remembered that pharmacists were responsible for the discovery of the elements oxygen, sodium, and potassium, the halogen elements, and the alkaline earth metals, and for much original work on such diverse substances as phosphorus, the mercurials, chloroform, the ethers and alkaloids." M. W. G.

Biochemistry—The Vitamins. R. K. CANNON. *Sci. Progr.*, **23,** 23–9 (July, 1928).—A report is given upon the progress which has been made in vitamin work during the past two or three years. A. E. C.

Biochemistry—Enzymes. R. K. CANNON. *Sci. Progr.*, **23,** 29–32 (July, 1928).—

A review is given of recent methods of purification, constitution, and cause of specificity of enzymes. A. E. C.

Physical Chemistry—the Electronic Theory of Valency. R. K. SCHOFIELD. *Sci. Progr.*, **23,** 32–7 (July, 1928). A. E. C.

The Cambridge University Chemical Laboratory. F. G. MANN. *Chem. & Ind.*, **47,** 690–6 (July 6, 1928).—A short history of chemistry at Cambridge from 1683, when John Francis Vigani became private tutor in chemistry and pharmacy, to the present time. Pictures of some of the buildings, laboratories, and of the men who have served as directors, are given. The article also includes a brief resumé of the research problems which have been studied at Cambridge. E. R. W.

Arrhenius Memorial Lecture. JAMES WALKER. *J. Chem. Soc.*, May, **1928,** 1380–401.—A complete account of Arrhenius' work and life, with portrait. M. W. G.

Friedrich Wöhler and Urea, 1928. EDITORIAL. *Am. J. Pharm.*, **100,** 431–3 (July, 1928). M. W. G.

Modern Alchemy. J. G. F. DRUSE. *Sci. Progr.*, **23,** 138–40 (July, 1928).—Attempts to transmute base metals into gold are supposed to have ceased at the close of the eighteenth century. During the nineteenth century several claims were made and later proved false. In recent times interest has again arisen from the phenomena associated with radioactivity. In 1919 Rutherford disintegrated atoms of nitrogen into hydrogen by bombardment with the alpha particles given off by radium. C. Ramsay's conversion of hydrogen into helium and copper into lithium has not been confirmed. Also recent attempts to obtain gold from mercury has not been proved. A. E. C.

The History of Chemistry. E. J. HOLMYARD. *Sci. Progr.*, **23,** 37–41 (July, 1928).—Brief reviews are given of books and articles on chemistry of antiquity, middle ages, and later times. A. E. C.

THE METHODS AND PHILOSOPHY OF EDUCATION

An Adventure in Common Sense Education. H. HOLT. *Sch. & Soc.*, **27,** 555–8 (May 12, 1928).—The author feels that the chief fault of the American college is "the insatiable impulse to expand materially." A college is made great by the quality of its faculty, its students, and the place where the teaching is done. The constant showing for expansion results in a larger, though not a better, student body. The buildings are more or less temporary and inharmonious while the professors receive a meager salary and have too many students.

Rollins College is definitely limited to 700 students with the aim "to perfect and dignify the small college." Its object is to give the student the best possible environment and to attract to its faculty men who are teachers and who can inspire students. Rollins would replace the lecture and recitation method with what it calls the "conference plan." "The theory is that the student's mind is immature, that he frequently does not know how to study and that the time when he most needs the professor's advice, help and supervision is when he is preparing his lesson and not after he has learned it or failed to learn it." K. S. H.

The Place of Professional Courses in the Liberal Arts College. H. G. GOOD. *Sch. & Soc.*, **27,** 709–13 (June 16, 1928).—Liberal education, like life, is too broad to define, the author says, and at best he can only explain its purpose, discuss the materials used, and point out the three functions of the liberal arts college, *i. e.*, "training in the use of intellectual tools, education for culture and character, and training in vocation." Today, people who can afford leisure aim at leadership and this has brought about an extension of many lines of work, particularly of the vocational type. Educators are now forced to meet the problem of combining cultural and vocational education to the greater advantage of society and of preparing for entrance in professional schools without compromising the liberal education. The author feels that the present method of allowing work done in a distinctly professional school to count toward a degree from a liberal arts college is most unfortunate. Mr. Good suggests a thorough study of these problems and says that careful attention should be given to developing a method that will show the interrelation of vocational preparation and a liberal education. K. S. H.

A Shift of Emphasis in Higher Education. W. T. SANGER. *Sch. & Soc.*, **27,** 743–5 (June 23, 1928).—President Little's attempts to matriculate every Michigan alumnus in some course of study indicates that this institution aims at reaching out beyond its campus edges in an endeavor to make education a life-long process. The author says that graduates now go out sophisticated and blasé, feeling that they are educated. Students should be taught that a college course is but a beginning while education for any career is a never-ending process and one in which the college is anxious to share.

Mr. Sanger prophesies the use of the radio in connection with adult education and discusses the possibility of broadcasting adult education courses. K. S. H.

The Testing Movement in the Light of Recent Research. EDWARD L. THORNDIKE. *J. Educ. Res.*, **17**, 345–9 (May, 1928).—Recent research indicates that psychological and educational tests will be made more accurate, more amenable to quantitative treatment, more significant of important facts of human ability and achievement, and more convenient to give and to score than has been hitherto possible.

Researches show that most or all of the "abilities" which our tests seek to measure have two features or "dimensions" expressed in two questions, "How difficult a task can his ability succeed with?" and "How many tasks are there at each level of difficulty?"

Theoretically, an ability which could just barely master all the tasks at any level could master all the tasks at any level below that and none at any level above it. Actually something approximating very closely to this theoretical expectation does occur if each task is extensive enough to depend approximately upon ability to understand one subject such as French and naught else. Any given person's ability appears then as an altitude reached in a surface whose width at the base expresses the number of tasks just barely above zero difficulty and whose width at any higher level expresses the number of tasks possessing the corresponding degree of difficulty. From the altitude and the shape and size of the surface a measure of the area—that is, the total extent or compass of the ability—is easily computed.

Through the construction of suitable tests, and the accurate scaling in equal units of difficulty, the way will be opened to full mathematical treatment of scores. Probably over three-fourths of the theoretical and practical matters in education concerning which test scores should be used, need scores which are in truly equal units and are referable to true zero-points. For sheer practical utility, the discovery of a valid means of scaling from zero up would be worth more than all of our present tests, highly as we should value them.

The advancement of knowledge by research is reducing the dangers to which the testing movement is subjected; that is, the publication of mediocre tests, and the commercial pressure on the part of publishers resulting in the sale of tests disregarding merit, and to individuals who may use them unwisely. Teachers are learning the fundamental lesson that an educational test serves to provide a measurement of a certain ability as a yardstick measures length and that what you infer from it is due to you, not to it. The gradual transformation of the older miscellany of tasks into a series of levels of increasing difficulty ascending from zero by known steps seems sure to reduce misunderstandings and misuses by teachers. R. M. P.

Concerning Transfer. EDITORIAL. *J. Educ. Res.*, **17**, 290–3 (April, 1928).—Most of the experiments regarding transfer have provided for the training of persons in one activity and have then sought to measure the performance of the same persons in another activity without training in the latter. Winch had pupils solve problems in arithmetic and then sought to measure improvement in reasoning with other material than arithmetic problems. No training was given between the initial and the final tests in this second field. Again, Bagley taught neatness in writing arithmetic papers and then attempted to measure improvement in neatness in spelling and language, no training being given in the writing of spelling and of language.

This avoidance of learning in the field in which transfer is being measured has been one of the principal items of method in experiments of this sort. Yet there are many practical considerations which made the application of this principle undesirable. The question is asked: why not actually train the subjects in the secondary function and measure the saving in time or in repetitions?

The author recognizes the validity of the saving method in the investigation of memory wherin the retention of a series of nonsense syllables is tested, not by seeing how many syllables can be repeated after an interval but rather by the saving in time or number of repetitions in re-learning the series. This saving is taken as a measure of retention due to the initial learning.

As long as Winch fails to train his subjects in reasoning with non-arithmetic material he fails to get a measure of all the "spread" from arithmetic material. Many children may be quite unable to reason successfully in the secondary field who could learn to do so easily after they had been trained in the primary field. This added ease of learning would be a measure of transfer.

It seems then that transfer is greater than investigators have shown. Much of it is potential, subliminal. It is where our college mathematics has gone. It has not entirely vanished. It is merely below the threshold.

Teaching always steers between total transfer and absence of transfer. It is prob-

able that neither complete transfer nor entire absence of transfer ever exists for all children. But the determination of the extent to which transfer from old training may be relied upon, and the extent to which additional teaching is demanded, requires the exercise of fine professional judgment. R. M. P.

The Orientation of College Freshmen. GLEN A. BLACKBURN. *Educ.*, **49**, 26–33 (Sept., 1928).—The author attempts "to indicate the progress already achieved in the orientation of college freshmen, and to point out some possible lines of development for the future."

There are two principal kinds of orientation courses. The first is the "preview course," which is strictly academic in nature and is somewhat specialized, as the Social Science course given at Clark University, or the "Nature of the World and of Man" given at the University of Chicago. Such courses are intended to acclimate the student to a rather broad field of learning, and are purely academic. The other course is the "campus orientation" course, which usually treats on such subjects as methods of study, social responsibilities of the student, problems of hygiene, religious activities and obligations, and other materials which will enable the new student to enter more comfortably and successfully into the life of the campus."

Results from questionnaires showed that out of 150 colleges replying only 11 failed to offer one of the three devices—intelligence tests, freshman orientation, or freshman week.

The aim of an orientation course could be: "supplying in convenient, timely, and impressive form a set of notions regarding student life which would supply the student with a point of view with which to confront his problems. The new student must get his ideas somewhere; why not expose him to a few notions originating from the faculty?"

"There are two opposite dangers confronting an orientation program. One pitfall consists in such prescription of the regime of the freshman and such assiduous shielding from all the jolts of college life that he becomes too docile and apathetic. On the other hand, there is the danger of causing the freshman to entertain the feeling that all the attention and ballyhoo are only a deserved recognition of His Majesty, the college freshman. This latter state of affairs would inevitably constrain the sophomores to unthrone the upstart at considerable cost of campus tranquillity. Either one of these false impressions should be avoided. Tractibility without apathy, and self-confidence without braggadocia is the golden mean." M. W. G.

A Source of Waste in the Professional Training of Teachers. D. A. WORCESTER. *J. Educ. Res.*, **17**, 117–24 (Feb., 1928).—The author shows that some content is repeated over and over again within and between departments; that because of this repetition and because of pre-information acquired professionally and from common sense, students are able to make high scores on examinations in courses prior to the formal pursuit of them. There is shown to be a tendency to give equal attention in instruction to that which is and to that which is not known. R. M. P.

The Place of Research in a Program of Curriculum Development. CHARLES H. JUDD. *J. Educ. Res.*, **17**, 313–23 (May, 1928).—The phenomenal educational upheaval which has transformed the curriculum of American schools is due not to educational research but to social pressure as the chief operating force. Even detailed changes in the methods of administering subjects have in many cases come because of social demand rather than because of any accepted principle of educational administration.

For example, the real cause of the reduction of mathematics to a minimum is that pupils dislike the subject, parents are in doubt as to its value, and teachers are exhausted in attempting to maintain standards. Critics find that fad after fad has been injected into the school program without reason or justification. That the situation should continue is unthinkable. The science of education has matured to the point where it can evaluate the results of instruction in quantitative terms, and any proposed change in the content of the curriculum must be submitted to rigid tests.

The science of education is today engaged in an effort to find some way of making a positive contribution to the curriculum to supply new content for teaching. If it can do something more than measure results, if it can show what should be introduced in place of the items of instruction which it marks as inappropriate, if it can anticipate social pressures in such a way as to prepare new contents for the curriculum before all the world outside the school insists on a change, then the scientific study of the curriculum will be a positive success.

Some typical efforts toward the extension of educational science into the field of curriculum development are cited. Teachers college selects the most progressive curricula and gives wide currency to these, a method of distributing the good rather than augmenting the actual present possessions of the schools.

Professor Rugg has canvassed the literature of social science and has arranged in order materials of cardinal importance, thus extending the school curriculum beyond what was formerly known to teachers. The new suggestions are borrowed materials, not materials contributed by the science of education. Professor Dewey and other workers have emphasized the relation of life in the school to the social life in the world at large, thus the schools are controlled by movements outside of themselves and their programs are enlarged; but the real source of the material is social life outside the schools.

This cursory summary is attempted because the author believes the methods hitherto employed have prepared the way for a long forward step.

It is clearly indicated that the school must go outside of its present program for much of the content of its new curriculum. What the author has to say is in no sense a repudiation of what has been done by Rugg, Dewey, Bobbitt, and Charters, whose work marks a trend.

Educators are asked to make an independent and pentrating analysis of social psychology. For instance, society has been transformed in its way of thinking and in its mode of behavior by the use of numbers. There is a new kind of psychology in the world because the number system has become a common possession.

The number system has given even to ordinary thinkers an attitude of precision which is enormously more significant than the ability to add or perform any particular calculation. It is the duty of educators to uncover all the essential factors which go to make up the psychology of civilization. Thus they should discover that the idea of precision has become a part of the warp and woof of the modern mind. An inquiry should then be made to discover whether this idea is present in the native equipment of pupils and thus determine whether that which is found to be important in social life needs to be introduced into the curriculum. It will be found that the idea of precision is not a native endowment of the human mind. The student of curriculum now faces the problem as to how the idea of precision may be presented to the individual mind so that this mind may gain all the advantages which come to mature people who possess this idea; and, further, how the individual may gain possession in such a form that this idea will enlarge itself and its applications in the course of individual development somewhat as it has done in the course of racial evolution.

The example serves to show that curriculum research requires penetration as well as industry. It must discover the direction in which civilization is moving. It must lead, not follow.

Research of the true type calls for a grasp of fundamentals. The research worker must discover the principles which will give intellectual unity to the mass of facts. Twenty or thirty cases are too slender and inadequate a basis to calculate correlations and pass judgment on the most intricate of educational problems. It seems to be true that the effort to make research workers out of a great many people has led to a superficiality which is well-nigh fatal.

Unless educational officers can look beneath the surface and find fundamentals, they certainly should accept what tradition hands down.

It is the author's belief that we are just at the beginning of an important era of productive scientific work. In curriculum studies there is a promising field for specialization in which anyone who has the proper training and real ability for research can make contributions of the highest significance. R. M. P.

Examinations and Education. A. V. LOCKHART. *Sch. & Soc.*, **27**, 725–6 (June 16, 1928).—The author stresses the fact that if a course is to be properly directed, a frequent check-up is necessary and even the cleverest of professors must have a personal, first-hand knowledge of each student's reaction to the teaching of a course. Not until teachers give as careful attention to teaching and its results as does a scientist to his research and its results will we have scientific teaching. K. S. H.

THE TEACHING PROFESSION

The Perfect Small House. R. S. BROOKS. *Sch. & Soc.*, **28**, 46–9 (July 14, 1928).—The manner in which Swarthmore College has met and solved the problem, common to all colleges, of economically housing her faculty is discussed in this article. K. S. H.

The world is blessed most by men who do things, and not by those who merely talk about them.—*James Oliver*

Local Activities and Opportunities

Through these columns, the JOURNAL desires to render a two-fold service.

1. Local Activities. Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' asssociations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of, personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. Opportunities. Providing an exchange column for positions. That is: (1) any teacher, who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed however the necessity for such action will be largely obviated.

Western Reserve University. DR. R. E. Burk, formerly holding a National Research Fellowship at Cornell, has been appointed Lecturer in Chemistry in the Graduate School and will have charge of special research on problems in catalysis. Owing to the crowded condition of the chemical laboratory, a special laboratory has been fitted up for him in an adjoining building.

Dr. Frank Hovorka has been promoted from Instructor to Associate Professor of Chemistry.

Miss Marion Cleaveland, who has been spending the past two years in the Graduate School of Columbia University, will return this fall and resume her work in the Department of Chemistry.

Dr. Phelan of Cornell University comes as Instructor in chemistry in place of Dr. E. L. Jackson, who resigned to take up work at Edgewood Arsenal.

Mr. George J. North, Cornell '28, has been awarded a fellowship in chemistry for the coming year.

St. Louis University School of Medicine. Dr. F. W. Laird of the University of Wisconsin has been appointed to the position made vacant by the resignation of Prof. W. G. Eversole, who has joined the staff of the University of Iowa. Dr. Laird will have charge of the work in physical chemistry.

Washington University, St. Louis, Mo. The chemical engineering curriculum has been changed so as to provide more time for a laboratory course in Principles of Chemical Engineering. In preparation for this work considerable small scale equipment has been installed during the past summer and it is now possible to introduce each student to the standard equipment for the carrying out of the more common engineering operations. In addition to this small scale apparatus, provision has been made for extensive study of industrial electrolytic methods. Equipment has been provided and special attention will be given to experiments with permeable diaphragm cells and to the electrodeposition of metals. Courses in metallurgy and fuels have been changed so as to become more engineering in nature. These courses are required of chemical engineering students only, so special attention is given to the applications of chemical engineering principles and practices in the field of metallurgy

and to the general subject of metallurgy as an aid to the chemical engineer.

Dr. John H. Gardner, a National Research Fellow, has been appointed associate professor of chemistry. He will have charge of the major portion of the research work in organic chemistry. Dr. Gardner was formerly connected with the University of Maryland and the University of West Virginia.

Mr. Stancil S. Cooper has been appointed instructor. His graduate work was done at the University of Pittsburgh.

Mr. Oscar G. Burch, formerly assistant, has been appointed Industrial Research Fellow.

Mr. Carl V. Benz of Washington University, Mr. John W. Neelly of Mississippi College, Mr. Carl H. Pottenger of DePauw University and Mr. Helmut C. Gutekunst of Illinois Wesleyan University have been appointed assistants in the department of chemistry.

Mr. Al Steyermark, M.S., 1928, has been appointed fellow in chemistry.

Professor P. A. Schaffer of the department of biological chemistry has been elected to the National Academy of Sciences.

Society of Chemical Industry. Dr. Arthur D. Little, who recently contributed an article on "Chemical Industry" to THIS JOURNAL (**5**, 641–55 (June, 1928)), president of Arthur D. Little, Inc., and of the Petroleum Chemical Corporation, was elected president of the Society of Chemical Industry at the recent New York meeting. The meeting of the Society in 1929 will be in Manchester, England.

The Lexington Regional Meeting, October 26th and 27th. The coöperating and invited sections sponsoring the Lexington Regional Meeting are Akron, Cleveland, Columbus, Cincinnati, Detroit, Erie, Michigan State College, Midland, Nashville, Ohio Northern, Pittsburgh, Toledo, University of Michigan, Indiana, Kanawha Valley, Louisville, Purdue, and the Kentucky Association of Chemistry Teachers, with the Lexington Section acting as host. Members of other Sections and their friends are invited to attend the meeting. Some papers have already been accepted from members of other Sections.

Lexington is at the center of a system of railroads and motor highways that make it accessible from every point. Come and enjoy the stimulation of scientific addresses, central Kentucky in late October, and the hospitality of Lexington.

The preliminary announcement of the general program follows:

FRIDAY, OCTOBER 26TH

8 A.M. Registration in the Chemistry Building, Kastle Hall, of the University of Kentucky, the Regional Headquarters for this meeting. The registration fee of $3.00 admits members and guests to all meetings, the Friday luncheon, the banquet and the football game.

9 A.M. and 2 P.M. Addresses by invited speakers and presentation of papers by Regional members and others in Kastle Hall. Among the speakers and their subjects will be:

S. W. Parr, University of Illinois, "Coal Carbonization."

A. S. Behrman, International Filter Co., Chicago, "Purification of Water by Electrodialysis."

H. S. Fry, University of Cincinnati, "A Plea for a Pragmatic System of Electronic Valence."

N. C. Cramer, E. B. Bloom, J. E. Day, Ohio Experiment Station, "The Catalytic Oxidation of Carbon."

W. L. Nelson, C. L. Butler, J. H. Cretcher, Pittsburgh, "Acid Polysaccharides."

E. A. Wildman, Earlham College, "Variations in the Acid Constituent of Local Anesthetics."

A. O. Snoddy, The Procter & Gamble Co., "A Laboratory Vacuum Pump."

Carl G. Campbell, Marshall College, "A Textbook in General Chemistry."

Nelson G. Turner, Baltimore Gas Engineering Corporation, "Naphthene Hydrocarbons."

J. S. McHargue, Kentucky Agricultural Experiment Station, "The Rôle of the Less Common Elements in Plant and Animal Metabolism."

C. H. Hunt, Ohio Agricultural Experiment Station, Wooster. "The Complex Nature of Vitamin B."

12.30 P.M. Luncheon at the University cafeteria.

5.00 P.M. Regional Executive Committee Meeting, Kastle Hall.

7.00 P.M. Banquet. Speakers, Neil E. Gordon, Johns Hopkins University, "Interdependence of Research and Teaching;" W. D. Harkins, University of Chicago, "Surfaces and Their Importance" (with lantern).

SATURDAY, OCTOBER 27TH

8 A.M. Optional tours through the Bluegrass, inspection of the new chemistry building, Kastle Hall, the Kentucky Agricultural Experiment Station, a visit to the famous old Library of Transylvania College, etc.

2.30 P.M. Football game—University of Kentucky vs. Centre College. Centre, the Kentucky College of Danville, which has won games from Harvard and other large institutions, is the traditional foe of the University of Kentucky and threatens the University this year. A ticket will be presented to each person registered.

University of Tennessee. The contract has been let for constructing the first unit of the new chemistry building. Ground was broken on September 12th and, according to the contract, the structure should be completed in 90 working days. The building is of brick construction with stone trimmings, and the type of architecture is Collegiate Gothic, since this conforms with the standard type adopted by the University. The new unit, when completely equipped, will house the departments of analytical chemistry, organic chemistry, and physical chemistry. Considerable space has been reserved for research purposes, since the department is very desirous of encouraging graduate study leading toward the master's degree.

Mr. Chas. R. Wimmer, an instructor in the department, has resigned in order to accept an assistantship at Yale. While there he will continue his graduate study toward the Ph.D. degree.

The Cincinnati Section, American Chemical Society. The 300th meeting of the Cincinnati Section of the A. C. S. was held on Wednesday, October 10, 1928.

In celebration of this event an informal dinner was served at the Hotel Alms at 6.30 P.M. John Uri Lloyd, Thomas H. Norton, Wm. Simonson, and Alfred Springer, charter members of the Section, and Ernst Twitchell, one of the Section's distinguished early chairmen, were invited guests of honor. Mayor Seasongood spoke in appreciation of the relation of the Section to the City of Cincinnati.

The speaker of the evening meeting, which was held at 8.15 P.M., in the Hotel Alms Ball Room, was Gerald L. Wendt, whose address was on "Research and the Human Spirit."

Finds Old Toothache Remedy Dangerous. A drug obtained from an East Indian plant called the gasubasu which has been used as a remedy for toothache for many years, has now been examined by a pharmacologist, Dr. E. Hesse of London, who has found that it is one of the most powerful surface anesthetics known, about 30 times stronger than cocaine. It has a most violent action on the heart, and strongly resembles the African arrow poison. Dr. Hesse considers that such a powerful poison is probably much too dangerous to be used generally as a local anesthetic.—*Science Service*

Recent Books

Nutrition. WALTER H. EDDY, Ph.D., Professor of Physiological Chemistry, Teachers College, Columbia University; Associate Director, Bureau of Foods and Sanitation, "Good Housekeeping Magazine." The Williams and Wilkins Company, Baltimore, 1928. vii + 237 pp., with 37 tables. 12.7 × 18.4 cm. $2.50.

The author's object in writing this book has been, he states, not to compile a guide to correct eating after the manner of a book on etiquette but rather to attempt to express in simple language the progress and the problems in the field of nutritional science. This he sets out to do by presenting some of the vital facts that have been discovered in this field from the point of view that their use will not necessarily result in the same reactions.

The first eight chapters are devoted to an attempt at making clear a point which modern advertising has sometimes obscured, namely, that the attainment of a good nutrition involves attention to many contributing factors and not to the use of any one particular food even though the merits of that article are beyond dispute. The remainder of the book is devoted to a rather detailed discussion of our newer knowledge of nutrition as it has been unfolded in a fifteen-year program of coöperative vitamin research. Dr. Eddy concludes his book "with full knowledge that it is not a complete guide to nutrition."

The author has covered his field fairly completely in a manner which leaves no doubt that the facts presented are, by and large, technically correct. The book has not been written for the specialist but rather for the layman that he may learn some of the fundamental principles which the nutrition experts have found necessary to follow in selecting proper food for man. Yet in spite of the author's assurances of simple language, one may well question the expediency of introducing in a treatise of this character such terms as lipins, glucides, acidosis, osmosis, and the use of chemical symbols without translation. It is unfortunate that Dr. Eddy should have drawn a parallel in nomenclature between cane and milk sugars on the one hand and so-called corn sugar on the other. It must be indeed irksome to those interested in the proper labeling of foods to read that one who is a colleague of "the father" of our present national food laws should have permitted himself this lapse of terminology for which there is no scientific basis.

The specialist would perhaps find much to criticize within its covers; the lay reader will find himself confused at times because of a lack of chemical background; but the teacher possessing some of the fundamentals of chemistry will find this book on the whole a valuable guide to a proper understanding of the scientific aspects of the selection of food.

H. A. SCHUETTE
UNIVERSITY OF WISCONSIN

The Determination of Hydrogen Ions. W. MANSFIELD CLARK, Ph.D., DeLamar Professor of Physiological Chemistry, The Johns Hopkins University. 3rd edition. The Williams & Wilkins Co., Baltimore, Md., 1928. xvi + 717 pp. 100 figures. 15 × 22.5 cm. $6.50.

It is always a pleasure to read the writings of Dr. Clark. One is never in doubt as to his exact meaning. This third edition of his well-known work is no exception.

Dr. Clark calls this book "An elementary treatise on electrode, indicator and supplementary methods." It is elementary in the sense that even one of very modest background can follow it with profit. Nevertheless, a moment's perusal

will convince one that it will fill, to a very great extent, the needs of the most advanced worker. Although Chapter XXX is devoted wholly to applications and particular cases, the aim of the book is to treat of fundamentals so as to give it maximum utility. No attempt has been made to include a discussion of all the uses of the hydrogen electrode. A large book is required to properly cover merely the essentials of the subject. As the author says, "this enlarged edition remains more elementary in relation to the needs of today than was the first edition in relation to the needs of its period."

The third edition has been expanded enormously as the following comparison will show.

	2nd edition	3rd edition
Pages	480	717
Chapters	21	30
Appendices, etc.	8	15
Pages of Bibliography	110	85
Figures	42	100

The bibliography alone has diminished. It has been made selective rather than comprehensive. This is because the number of papers on the subject has been increasing almost logarithmically with time. The book has been almost entirely rewritten to accord with recent developments. The color chart has been very greatly improved. Most of the chapters are now prefaced by a quotation—sometimes whimsical, always pointed. Among the figures are included fine cuts of S. P. L. Sorensen, Svante Arrhenius, and Leonor Michaelis. Among the newer material one finds an expanded chapter on the choice of indicators, chapters on spectrophotometry and colorimetry, on free energy changes on quinhydrone and similar half cells; on metal oxide, oxygen and glass electrodes; on the theory of Debye and Hückel; on non-aqueous solutions, etc.

No really serious adverse criticism can be raised. One wonders whether the inclusion of a chapter on the interionic attraction theory of Debye and Hückel is a real necessity at this time, but is nevertheless pleased to have the author's discussion of it available.

In conclusion, it is the reviewer's opinion that this is more than just another "new edition." It is so incomparably superior to the earlier editions that one may view it as a new book, rendering them obsolete. Certainly no teacher or advanced worker will fail to have it on his bookshelf.

MALCOLM M. HARING

UNIVERSITY OF MARYLAND

Nitroglycerine and Nitroglycerine Explosives. PHOKION NAOÚM, Ph.D., Director of Scientific Laboratories, Alfred Nobel Dynamite Company, Hamburg, Germany. Authorized English translation with notes and additions by E. M. Symmes, Hercules Powder Company, Wilmington, Delaware. The Williams & Wilkins Company, Baltimore, 1928. xi + 469 pp. Illustrated. 15 × 22.8 cm. $7.00.

This book is the first to be published of the projected World Wide Chemical Series, under the general editorship of Professor E. Emmet Reid of The Johns Hopkins University. It describes the chemistry and manufacture of the most important of the peacetime explosives—and the civil uses of explosives are far more important than their military ones. Nitroglycerine explosives are used in engineering operations, for the building of canals, bridges, railroads, etc., and in coal and metal mining which lead to the production of comfort and of power, of steel, and of manufactured articles of all kinds. The book, therefore, describes the science and the art of an industry which has been of great importance in making the world smaller and is fundamental to the maintenance of the present industrial civilization.

After an introductory chapter on the history of the subject, the book contains three principal sections which deal respectively with Nitroglycerine, with Homologous and Related Nitric Esters, and with

Nitroglycerine Explosives. These are followed by a Supplement on the analysis of nitroglycerine explosives, and by adequate author and subject indexes. The laboratory preparation of nitroglycerine and of the other nitric esters is described, their chemical, physical, and physiological properties are discussed, and plant scale manufacture of the explosive materials and of the finished explosives in cartridges is set forth in detail and illustrated with cuts of apparatus and machinery. The translator has described American practice, pointing out the respects in which it differs from the German. The laboratory sources of the knowledge behind the industry are mentioned with references. The reader feels that nitroglycerine explosives have been produced by research and that the research is still going on.

The work is authoritative and will be accepted as standard. It is printed on unglazed and unweighted paper, and is light in the hands—a pleasure to handle. It augurs well for the Series which it initiates.

TENNEY L. DAVIS
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Notable New England Chemists. LYMAN C. NEWELL, Boston University, and TENNEY L. DAVIS, Mass. Inst. of Technology, 1928. 15 × 22.5 cm.

This pamphlet was prepared by the Division of History of Chemistry, American Chemical Society. It was distributed to registered members of the Division at the Swampscott meeting of the Society, September 10–14, 1928.

Extra copies may be obtained from the Secretary of the Division, Professor Tenney L. Davis, Mass. Inst. of Technology, Cambridge, Mass., for fifty cents each.

Portraits and notes on the following men are contained therein: John Winthrop, Jr.; Lyman Spalding; Benjamin Silliman; Parker Cleaveland; Oliver Payson Hubbard; Eben Norton Horsford; Wolcott Gibbs; Josiah Parsons Cooke, Jr.; Thomas Sterry Hunt; Francis Humphreys Storer; Charles William Eliot; James Mason Crafts; Josiah Willard Gibbs; Theodore William Richards.

This pamphlet is section one, pages 9–24, of a larger booklet pertaining to the Swampscott Meeting of the A. C. S. Additional material contained in this latter publication includes the following.

"The Industries of New England" are described on pages 25–36.

Notes on the early history of the New England States—"From Cape Cod to Concord"—occupy pages 37–50.

The important place which education has always held in New England is brought out in "Higher Education in New England," pages 51–74, which portion includes a list of the various institutions of learning in that locality, with illustrations and comments on each.

A note, pages 75–77, on "Du Pont in the Coated Textile Field," calls the reader's attention to the artistic and attractive Fabrikoid binding of the booklet.

This material will be useful and suggestive to those interested in chemical education.

M. W. G.

Study Questions and Problems in Inorganic Chemistry for Colleges and Universities. ALEXANDER SILVERMANN. 2nd edition. D. Van Nostrand Co., Inc., New York City, 1928. vi + 97 pp. 23.5 × 15.25 cm. $1.00.

A long list of reference books accompanies these questions, which are arranged systematically for use with any standard first-year chemistry text.

M. W. G.

The Laboratory is published every two months, except during the summer, by the Technical Service Department of the Fisher Scientific Company, Pittsburgh, Pa. 15 × 23 cm.

The series (four numbers have already been published) is available to chemists upon application.